THE

ELECTRICAL REVIEW.

VOL. XXXV. SEPTEMBER 14, 1894. No. 877

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THE ECONOMICAL ASPECTS OF ELECTRIC TRACTION.

AFTER electric lighting, the main branch in the development of electricity is clearly that of traction. While we have never shared the too sanguine views of those who would at once relegate the steam locomotive to the museums, we are none the less hopeful of the future of electrical traction. Indeed, no one who has read sympathetically the early history of steam locomotion can fail to see that the early successes were, on the whole, in no sense in advance of what even the sceptical must admit is a magnificent success, if he should happen to take a journey on the Liverpool overhead line or the South London Railway. The Liverpool line more particularly stands out as an example of electrical traction. It is fully exposed to view, all Liverpool can see its frequent service of trains along the main highway of the city—the dock frontage. In this respect the older South London line is of less educational value. Only passengers can see it at all, and they can see very little of it. It has been considerably discredited by exaggerated reports concerning one or two early mishaps. Its managers—in company with the managers of everything connected with South London, from railways to water supply—have shown an ignorance of the public mind in chopping and changing the fares, and no provision has been made for ventilation, as though it were expected that electrically worked lines needed none, even if buried 90 feet below surface. Thus it is that the Liverpool line seems to stand out prominently as a landmark in the history of the new mode of traction. From the latest published figures some idea may be gleaned of the economic aspect of this latest power. The London line—only a little over three miles long—carried nearly 2½ million passengers in a half-year, and its expenses were close upon 80 per cent. of the receipts. Now, with a passenger traffic closely approaching 3½ millions in the same time, the ratio is under 62 per cent. How does this bear on the Liverpool outlook? The line there is about six miles long. During its first 17 weeks of running it carried passengers at the rate of about $2\frac{1}{10}$ millions per half-year, and the expenditure ratio was only 56½ per cent. Two subsequent half-years show respectively nearly 2½ millions and nearly 3 million passengers, and yet the expenditure has gone up to nearly 75 per cent. Now this is not due to bad management of the electrical department, for the total cost per train mile has fallen from 15·41 to 13·52d., while the London cost is still 15·82d. per train mile, to which it also has dropped from 21·35d. The trouble at Liverpool is the enormous drop in the receipts per train mile. While the London line still enjoys receipts of 25½d. and never had 27½d., the Liverpool receipts have dropped from 27·23d. to nearly 18d. Still the number of passengers is growing—has grown much faster than did the London traffic, and we can only conclude

that the trains have been increased in number more quickly than the passengers have arrived to fill them. There may be policy in this, though it naturally suggests that trains must often run very empty, and if a frequent service is desirable, it might be made with one car trains, thereby cutting down locomotive power probably 1½d., and reducing general wear. The Liverpool line is burdened with the extra dead load incidental to two classes of passengers, and this in order to secure a traffic formerly carried by ordinary omnibuses. With a single class there would be a saving in train loads. Clearly, however, with more passengers, the ratio of expenditure will improve, and as there is not a loss now, it may be wise to continue the two car trains. We may learn from a general review of the facts, that in the present condition of electrical knowledge and experience, a route which will supply traffic for a frequent train service may be expected to pay; that such a traffic, especially with stations placed at irregular distances, is fairly suited to electrical requirements in respect of the generating station, and the desirability of a fairly uniform load upon it; but, at the same time, it appears that the frequent starting of the trains and the waste of the stored energy at the brake blocks adds seriously to the motive power cost.

The hydraulic parallel so frequently drawn as to the behaviour of electricity, unfortunately holds good with regard to the quoted waste of energy of a turbine starting slowly against a load. If not already existing, the future may bring forth means of overcoming this difficulty with electric traction, and it is to be greatly desired that it should, seeing how the new motive power appears, for a time at least, to find its best field of work in the class of railroad having frequent stoppages, and calling, therefore, for an equal number of wasteful startings. If the future should also disclose some practical means of storing the energy of a retarding train to be given out in the work of acceleration, another source of loss will be swept away. With such a line as that at Liverpool, with an ample supply of condensing water, there is no reason why an indicated horse-power should require more than 1·5 to 1·7 lb. of coal per hour, or, say, 2 lbs. per E.H.P., as the combined result of boilers, engines and dynamos, and this will compare most favourably with steam locomotives which weigh so very much per ton of train, and are apt to become proportionately heavier for light trains. The steam locomotive is not on the whole a wasteful combination. Being non-condensing, it naturally has a heavier coal consumption than a high class stationary condensing engine which is not confined within a given space, but it is singularly elastic in its capacity, and does not run to waste at low speeds when doing little work. Hence it makes up for its more liberal fuel consumption by this one virtue, and when this advantage is discounted, by reason of some future electrical improvement, the electric motor will be in a very much better position than now. As matters now stand, however, electric traction on a railroad is proved to be a success, and only awaits the step by step improvements whereby it shall become still better. It has gone past the critical moment at which any suggestion of abandonment could be made. With tramways, however, the case is less hopeful; the underground conduit has not proved an unqualified success with its narrow surface slot, and difficulties as to water and dirt. Accumulators, heavy and cumbrous though they be, might have been a success had they possessed durability. The very nature of their construction is sufficient to raise a doubt as to their suitability on a wheeled carriage, however suitable on a smooth running launch, for which accumulators seem perfectly feasible, indeed, have proved so. The only means yet to hand for successful street traction is that of the overhead line and poles.

There are objections to this system. Architects hold up their hands in horror at the mention of it, so much so that one would almost imagine that the architects of to-day were a sort of apostolic successors to those of the eleventh century. As a fact, however, how many buildings are there of modern architects' design from which it would not be a positive relief to turn and look upon a neatly-wired tapering steel pole, serving the double purpose of carrying the street lamps and the traction wires? Are there not, further, in some of our most beautiful country roads rough poles carrying Post Office wires, scarcely less rough than those which once stood along Broadway, New York City? Is it to be seriously contended that such thoroughfares as the Mile End Road, or the Oldham and Rochdale Roads, in Manchester, would suffer in appearance by the erection of the traction wires and poles? When we consider the sanitary aspect of the tramway question, and the amount of unavoidable cruelty to animals that is involved in horse traction, we may well set these off against the imaginary evils of the pole system. This is a conclusion to which we have not come hastily. We have been of those who would like to have seen other means successful; but, so far, there is no other means in view. A comparison of the South Staffordshire pole-line, with its 4·06 pence per car mile, and the Birmingham accumulator line at 11·59 pence per car mile for motive power, &c., tells its own story. But after all, this failure is one of detail only—not one of principle. It is the failure of an attempt to use accumulators for an unsuitable duty, where they would not have been continued but for the opposition of the municipality, which has refused to allow the erection of poles and overhead wires. Can it be that a municipality once known as progressive has taken a cue from a former mayor and gone back on itself in an attempt to appear staid and respectable?

Taking a broad view of electrical traction, it may fairly be said that upon a fenced in railroad where engineers can dispose their conductors as they please, its success is beyond question; that an almost equal success may be claimed for the overhead pole or trolley system, but that as regards accumulator work the evidence is against it, pending something different and more durable under vibration than existing secondary cells.

Mere passenger traffic, however, does not cover the field of electric traction. On canals it would seem to have a future, and as these lines of communication may be classed with the fenced in railroads, either the pole or the accumulator system with propeller or with sunk chain can be employed at will. There is nothing in the motion of a canal boat to seriously disturb an accumulator cell.

Electrical engineers may take heart at the achievements of the past, and look forward with confidence to the future. Mistakes have been made, and may happen again. It is possible that energy has been wasted over the question of steam production and use, which might have been better applied to solving electrical problems. Every improvement will widen the field of usefulness, and in extending the use of electricity, the existing successful undertakings can un-

hesitatingly be advanced as powerful arguments wherewith to silence opposition. There are now working figures to advance, and so long as engineers avoid experimental and speculative work, they will gain the public confidence, and the necessary funds for rational attempts at improvement will be forthcoming.

ALTERNATING v. CONTINUOUS ARC LAMPS.

From a user's point of view, the continuous current arc lamp is in many ways to be preferred to the alternating lamp. It is silent, its light is thrown downwards, it burns cheaper carbons, and, above all, the troublesome question of "frequency" has not to be reckoned with. A continuous current lamp can also be purchased from any maker, and it can be placed on any continuous current circuit. With alternating arcs, however, it is necessary that they should be wound for the frequency of the particular circuit for which they are required. It is marvellous that electrical engineers should have perpetuated the insane practice of using so many different "frequencies." It is unquestionably detrimental to the advance of the alternating arc lamp business. We have always held that the frequency should be fixed at something about 60°; it should never on public supplies exceed 65, or be less than 50. If such an uniformity were made compulsory, the benefit both to arc lamp makers and users would be enormous. It would, at the same time, give an immense impetus to the alternating motor business.

Those who use arc lamps have, generally speaking, little choice in the matter of selection. By the wise dispensation of the electrical providence, it is ordained that they shall be supplied with a certain kind of current; and so, in selecting an arc lamp, it is often a case of "Hobson's choice." Arc lamps would be much cheaper and much more extensively used if only one kind of current were supplied for arc lamps, and that continuous; as matters stand the best that can be done is to reduce the number of different currents to two, continuous and alternating, and not go on with half-a-dozen different alternating currents, each requiring specially wound lamps.

Where a large number of arc lamps are used, it would pay to employ a rectifying commutator and run the lamps with the unidirection pulsating current, but where only half-a-dozen arc lamps were used it would be too expensive and troublesome to use such a commutating device.

The electricity supply of the future will be one that will give either alternating or continuous current, according to the desire of the consumer. When this electrical millenium arrives, we have no hesitation in predicting that the alternating arc lamp will be crowded out by its rival.

We know of a case where a user of arc lamps has a warehouse situated in an alternating current district and another warehouse in a continuous current district. The difference in the light, the absence of noise and the economy in current, are all largely in favour of the continuous current.

From the manufacturer's point of view, the only difficulty is the necessity for making different kinds of lamps where one common kind might suffice. As things are, he has to wind lamps for all the different currents and different frequencies from 40 to 133 per second, and with his motors he is confronted with the same stupid difficulty. For photographic purposes the continuous current arc is much superior, and in search light projectors it is far better than the alternating, the crater formed on the positive carbon being of great advantage in both these cases.

The moral of all this seems to be that we are face to face with a "long felt want," in the shape of a cheap and efficient means of transforming from alternating to continuous current.

A Point in Electro-chemical Economy.

Amongst other results the perfecting of electro-chemical processes of manufacture is likely to involve the transference of many industries to mountainous or hilly districts where plenty of cheap water-power is available. The actual cost of a H.P. as produced by water-power and by steam-power can only be obtained accurately with considerable difficulty, owing to the uncertainty of many of the factors; but in the case of large installations, current opinion greatly favours water-power. Allowing 2½ per cent. for depreciation, Profs. Houston and Kennelly arrived at a cost of about 12s. per H.P. per annum for uninterrupted work at the Niagara 120,000 H.P. installation. But for steam plant of this size, a far larger sum would have to be written off for repairs and depreciation, and the cost would amount to from 20 to 30 times the sum named. There is little doubt that where there is a sufficient and convenient head of water, such comparatively small installations as would be required in chemical works could be run more cheaply by water than by steam. As a case in point, the *Zeitschrift für Elektrotech. u Elektrochem.* cites potassium chlorate, a substance which has recently grown into an important commercial product owing to its use in the manufacture of safety matches. This salt was at first exclusively made in England; then French and German manufacturers entered the field, and now about 600,000 kilogrammes out of the 1½—2 million kilogrammes required annually are made in Vallorbes, where an absorption of 2,000 H.P. of water-power produces the chlorate by the electrolysis of potassium chloride at a greatly reduced selling price. A much larger installation has been laid down at Månsboe in Dalecarlia (Sweden), with water-power equal to 6,500 H.P.; and here the promoters estimate the cost per H.P. at one-tenth of that which obtains in England. The transference of this one small industry from this country to other countries is of itself unimportant, comparatively speaking, but it behoves chemical manufacturers, where water-power is not available, to watch the progress of electro-chemical methods and to be prepared to meet the competition of manufacturers in other countries where inaccessibility and similar disadvantages are far more than counter-balanced by the natural advantages of a high and available water pressure.

Photometry and Pupillometry.

Some time ago a method of photometry was proposed by Gorham which was based upon the physiological fact that the pupil of the eye dilates and contracts according to the intensity of the light which falls upon it. It was argued that if two sources of light produce the same area of aperture in the pupil of the eye of an observer the intensities of the two sources of light must be equal. Gorham's instrument effected an accurate measurement of this area and was capable of being used therefore for photometric purposes. The deductions, however, are somewhat discounted from the fact that other circumstances act upon the pupil and influence its area besides the intensity, for example, the size of the image of the light that is thrown upon the retina. Various investigators have endeavoured to devise means whereby these measurements shall become absolute, and in a series of papers recently published in the *Journal Universel d'Electricité*, commencing with Vol. lii., No. 23, p. 451, these are reviewed and discussed by Mons. Charles Henry, who contributes some valuable mathematics to our knowledge of the subject. We recommend their careful perusal by all those who are specially interested in the measurement of light.

ELECTRICITY DIRECT FROM COAL.

The solution of this momentous problem has been discussed in a remarkably able manner by Dr. Ostwald, before the German Institute of Electrical Engineers. Such discussions are exceedingly valuable in turning the thoughts of inventors and others engaged in research into proper channels, for, although no practical solution may be put forward or even foreshadowed, the marshalling of facts by a master in the sciences and the interpretation of their relation to one another, has a significance of the utmost value.

The science of electro-chemistry is just emerging as a distinct subject from the two sciences of chemistry and electricity. A great mass of facts are known, one half of them belonging to the chemist and the other half to the electrician. The electro-chemist takes this knowledge, examines it with the eye of the chemist, and also with the eye of the electrician, and gradually there is evolved the exact science of electro-chemistry. The great Faraday was an electro-chemist, and many of his most valuable discoveries are due to that fact; and the greatest problem now before the engineer, the chemist, the electrician, and physicist, namely, the generation of electricity direct from fuel, belongs to the science of electro-chemistry.

The ordinary galvanic battery generates electrical energy direct from fuel, but hitherto has the two fatal drawbacks of the necessity for the use of very expensive fuel, zinc and acid; and secondly, the difficulty of getting rid of the waste products immediately they are formed.

Not a little of the steam engineer's success is due to the delightfully simple methods and materials he employs. As a source of energy he uses coal, which is plentifully found ready for his use; this with air provides his heat in such abundance that he can afford to waste 90 per cent. of it and then generate electrical energy with his engine and dynamo much cheaper than the electrician can generate it direct from his fuels, zinc and prepared chemicals. Considering the immense amount of energy stored in coal, it is dirt cheap at usual prices; the air costs the engineer nothing, and, as a rule, water costs him next to nothing, and all three can be got without manufacturing almost anywhere in the habitable world. Then, as for the waste products, those from the furnace take themselves off at once through the chimney, and the ashes and clinkers are also easily removed, while the exhaust steam flies into the atmosphere or condenser.

In the galvanic cell the waste products accumulate and clog it, and the bigger the cell the worse becomes this trouble.

Dr. Ostwald suggests the use of the same elements by the electrician, which are so successfully used by the engineer, so that we may produce electricity direct from coal and air, the waste product being carbonic acid gas which would itself escape, or which might be utilised. How such a cell or battery is to be made is as yet as great a mystery as ever, but Dr. Ostwald's remarks on the subject are worth perusing, and we give an abstract of his paper which deals with this part of the subject of electro-chemistry.

"The maximum of energy that can be obtained by any one change of energy is theoretically independent of the process by which the change is effected. Therefore, if we could transform into mechanical energy the chemical energy of the combustible without resorting to heat, we should not be tied then to the uncomfortably high temperatures, and might gain the entire amount without those discomforts.

"If we produce a galvanic element which furnishes electrical energy from coal and the oxygen of the air, and furnishes it in amounts somewhat in proportion to the theoretical values, then we shall face a technical revolution in comparison with which the one following the invention of the steam-engine will be dwarfed into insignificance. Think of the incomparably simple and elastic distribution of electric energy and imagine the change in the appearance of our industrial centres. No smoke, no soot, no boilers, no steam-engines, nay, even no fire, for fire will be needed only in the few processes which cannot be accomplished by electricity, and of those there will be fewer every day.

"The energy of the galvanic element originates in the chemical energy; that is indubitable. But not all chemical energy is changed into electrical energy. What then are the conditions for which the transformation is as complete as possible? Only the indirect chemical processes are electrically utilised!

"Suppose we should take two vessels containing each a solution of potassium sulphate and connected by a filled siphon. We put a rod of zinc into the one and a rod of platinum into the other vessel. If we connect the two metals over a galvanometer, a current of but very short duration occurs and the needle of the galvanometer comes directly to rest again. We know this to be the consequence of the polarisation, and also know that a continuous current may be obtained by the employment of an acid in place of the neutral fluid. Suppose we employ sulphuric acid. Into which of the two vessels would you want me to pour it to produce a current? Whosoever had this question put to him unhesitatingly answered: to the zinc, of course, for the zinc must dissolve! But, my asking the question may convey the hint that the matter is different. We pour the acid to the zinc—no action! We pour it to the platinum, and we perceive the needle fly to the stop.

"We arrive thus at the seemingly absurd result that the acid must be poured into the vessel not containing the substance on which it is to act. That applies quite universally. Some years ago I published a long series of experiments which proved the validity of this principle for entirely different reactions. And that is by no means an unforeseen or unexplainable fact, but the experiments were made because I had to expect the demonstrated phenonoma from the theory which at that time was only just shaping, although at first blush they appeared scarcely plausible.

"But if we bestow some more thought upon the nature of these processes we soon perceive that they could not possibly take a different course. If the zinc is to dissolve it must form ions, and to that end take up a certain quantity of positive electricity. To make this possible an even quantity of positive electricity must leave the solution, so that an equivalent quantity of hydrogen relinquishes its ionite existence and is transformed into common hydrogen. The discharge by the fluid of positive electricity cannot take place at the spot where zinc dissolves, for there the electricity is moving in the opposite direction. There is therefore no alternative but for hydrogen to escape at the cathode conform to the actual occurrence.

"The explanation plainly shows the futility of the procedure of the late Jablochkoff when, some years ago, he tried to produce electrical energy from coal direct. He put the coal into melting nitre from which to obtain oxygen, and the resulting violent combustion actually generated current, but so weak a one that it could not be utilised. Now we clearly perceive the reason of his failure: the nitre does not belong with the oxidable electrode, but with one not attacked by oxygen. Surely in the Bunsen element we do not pour the nitric acid on the oxidable material, zinc, but on the coal, which under these conditions is not oxidable.

"Therefore, our future coal element will have the oxidising medium on the side not containing the coal to be burned, and that medium must either be the oxygen of the air itself or some other oxidising substance produceable in quantities from the same. In its chemical process such an element would be like an ordinary stove. Coal is shoveled in at one side and oxygen admitted from the other; carbonic acid escapes as product of the reciprocal action. A suitable electrolyte has still to be added to bring about the electrical process. The electrolyte only acts as an interposed substance and will not be consumed."

OIL ENGINES.

The *Engineer*, of August 24th, calls attention to what it considers is a peculiarity in this class of motor. Referring to the Cambridge trials, which did not present anything very new in oil engines, our contemporary observes that the engines exhibited may be divided into two main classes—those which had and those which had not independent vaporisers, two classes not widely different in working, though perhaps different in structural details. In the one the oil is vaporised in the working cylinder, utilising the residual heat of previous charges or rather heat stored up in a suitable vaporising surface. This vaporises each fresh

charge, and with the mechanically produced heat of the compression also fires it. This certainly seems simple, and, as our contemporary observes, one feels that it should secure the best economy. Nevertheless as good or better results are obtained with engines having separate vaporisers heated by an external lamp, the heat of which, except such portion as passes into the vaporiser, is lost. True, the oil used by the lamps is but a small part of the total oil consumed, nevertheless it is a quantity that is not used at all in the first type. Yet the engine with the lamp not only uses less oil per brake horse-power, but does this with less oil in the cylinder by the quantity used externally in the vaporising lamp. The *Engineer* cannot understand this—cannot see why an engine which uses all the oil in the cylinder, and therefore all the heat it gives, does not stand first in economy.

It is only a partial statement of the case to say that whether the entropy acquired during evaporation is due to heat supplied inside the cylinder, or to heat supplied by an external source, its value is the same; for apart from the less efficient use of the externally burned lamp oil, the engine which heats and vaporises the oil in the cylinder loses or imparts so much less heat to the jacket coating water, or may be supposed to do so. So long as we feel sure of our thermo-dynamic knowledge we have a right to say to this that while on the face of it the simple or self-vaporising engine should be the more economical, there must be causes acting to prevent this, and it is easy to understand that these may not be far to seek even if they cannot be at once located. All internal combustion engines suffer necessarily by reason of their water jackets, and it is not an easy matter to explain just what is the action of the jacket at any particular period of a revolution. That the water jacket is absolutely pernicious in an economical sense is, of course, undoubted. Its existence is merely a concession to poverty of material from which to make cylinders and pistons. Then again, is the *Engineer* assured that in the simple engine the oil is vaporised thoroughly? There seems to us a possibility that not only may vaporisation be delayed, but that oil may go out unconsumed with the exhaust, or like the water in the steam engine, may evaporate during the exhaust stroke and go to waste.

What are the analyses of the residual or exhaust gases? Is there anything that will bear out such a suggestion? No figures are adduced showing that of the two classes of engine there is not some difference in dimensions, or in mode of working, sufficient to explain the apparent anomaly. An oil may be vaporised and during compression may be condensed again under the combined influence of increased pressure and jacket cold, and the vaporisation may be less perfect than could be wished; there may be less permanency in the gas produced. Then again, for combustion is so delicate an operation that small things will greatly influence it, are the products of combustion different? is there more carbonic oxide produced in one case than the other? for, if so, this would account for much in the light of the very small calorific effect of carbon burned to its monoxide.

There are a host of practical points to be determined in the working of oil engines, and these, we think, might be treated in a more practical manner than that adopted by the *Engineer*, whose article has too much of the appearance of a setting for that blessed word "entropy" to be valued by practical men who have worked up the oil engine to its present state and don't care much for "entropy" as one might gather from the correspondence columns of the *Engineer* itself.

THE HANLEY ELECTRICITY WORKS.

The lighting by electricity of Hanley has been carried out by the Brush Electrical Engineering Company, Limited, under the supervision of the borough engineer, Mr. Lobley. The inauguration took place on July 26th, 1894, but the Corporation had provided a continuous supply throughout the principal streets for sometime previous to that date.

The generating station is situated on land adjoining the canal and Bethesda Road. The engine-room is 67 feet 3 inches long, by 35 feet wide. The boiler-house, and the arc light and condenser house are each 50 feet long by 30 feet 4 inches wide; and the buildings, which have been carried out under the supervision of Mr. Joseph Lobley, M.I.C.E., the borough engineer, have been specially designed to facilitate the carrying out of future extensions.

Steam is supplied to the first instalment of plant from three Lancashire boilers, each 28 feet long by 7 feet in diameter. Each boiler is fitted with all the latest improvements, being constructed for a working pressure of 140 lbs. per square inch; and mechanical stokers are used for firing. Coal is landed direct from the barge on to a platform, from which it is fed by chutes into the stokers; thus is secured the utmost economy in labour and fuel.

The main pipe is of wrought-iron, 6 inches in diameter, and forms a ring, with valves so arranged that any section may be isolated. The branches to the main engines are 4 inches and 3 inches in diameter. The whole of the valves are of the parallel slide type, so that when open the steam has a straight passage through. The exhaust piping, which is of cast-iron, ranging from 9 inches downwards, opens into the condensers or direct to the atmosphere as may be desired. There is an automatic relief valve on the pipe which opens the exhaust to the atmosphere in the event of stoppage of the condensing plant; while a valve is also provided for shutting off the condenser when required.

The condensing plant is so arranged that it may be readily extended along with the engines. At present there is one surface condenser of 1,000 square feet cooling surface, and the cooling water is taken from the canal. The Raworth air and circulating pumps, which are horizontal, are fixed on one bedplate, and are driven by a pair of compound cylinders; while a heavy fly-wheel is provided to enable the steam to be cut off and used expansively.

The principal feed pumps are driven by the same engine as the air and circulating pumps from a rocking shaft. The pump rods are attached to blocks which slide in slotted levers, by means of which the stroke may be varied as required. The feed water is taken from the hot well under the air pump. In addition there is a wall feed pump, supplied as a stand by arranged to pump from the cold water supply direct or from a tank which is heated by exhaust steam. This pump is equal in capacity to the full power of all the boilers.

The main engines for private supply are at present four in number—two of 200 I.H.P. and two of 100 I.H.P., and are of the well-known Brush compound vertical type. The 200 I.H.P. engines have cylinders 15 inches by 25 inches by 16 inches stroke, and run at 167 revolutions per minute, while the 100 I.H.P. engines have cylinders 11 inches by 18 inches by 12 inches stroke, running at 200 revolutions per minute. The H.P. cylinders are fitted with piston valves, and the L.P. with ordinary slide valves. They are controlled by a fly-wheel governor, acting on the high-pressure valve. The governor is fitted with Raworth's patent adjustment for altering the speed whilst running, and for dividing the load as required between the various machines running in parallel. The L.P. slide valves are provided with Hackworth gear for varying the cut off in the L.P. cylinder whilst running, so that the engines may be operated with the best results for any load.

The alternators, which are of the well-known Mordey Victoria type, are driven from the above engines by means of separate cotton ropes. Two of these run at 430 revolutions per minute, and have a capacity of 100 kilowatts each, whilst the other two run at 600, and have a capacity of 50 kilowatts each, the pressure being in each case 2,000 volts. The armatures are stationary as usual in this type, while the field-magnets revolve; these alternators work perfectly in parallel with each other, irrespective of size. The lubrication of the bearings is automatic, being effected by means of small pumps, which keep up a constant circulation of oil.

The exciters consist of two Brush Victoria dynamos, each having an output of 10,000 watts, and being capable of exciting all the alternators. They are driven by short belts direct from pulleys keyed to the shafts of the two 50 kw. alternators.

The unit system introduced by the Brush Company has been carried out very thoroughly in this station; each exciter has a switchboard arranged for running the exciter in parallel on to the exciter omnibus bars. Platinoid resistances, wound on bars of slate with a sliding contact, are used in the shunt circuit for regulating the pressure of the exciters, and through them of the whole station. The station voltmeter is fixed

near these resistances. Opposite each alternator is a board containing double-pole high tension fuses and switches for connecting the machine to the station omnibus bars, also an alternate current ammeter, a voltmeter, and an ammeter on the field circuit. There is also a small plug connecting the alternator to the synchroniser.

The synchroniser board contains two synchronisers and lamps, together with double-pole switches for connecting the synchroniser to the station omnibus bars. It also carries the main station ammeter, and the main station recording meter, which is of the Schallenberger type. After passing through this board from the alternators the omnibus mains proceed to the circuit boards, of which at present there are two. Each is fitted with an ammeter and double-pole high tension switch and fuse. The system allows of the addition of any number of exciters, alternators, circuits, and their corresponding boards, without in any way interfering with the existing arrangements.

The whole of the engine room plant has been manufactured by the Brush Company at their Loughborough Works.

The distribution is effected by low tension distributing mains at 100 volts pressure running from the transformer sub-stations, which are situated at convenient points in the town. These mains consist of a pair of copper cables, of 100 per cent. conductivity, insulated with vulcanised bitumen and laid in a cast-iron trough, run in solid with refined bitumen. The case is covered by a cast-iron lid laid over the bitumen. The high tension feeder mains consist of concentric copper cables of 100 per cent. conductivity, highly insulated with vulcanised rubber and tape; they are braided with tarred hemp yarn, and compounded, and are drawn into cast-iron socket pipes, coated inside and out with preservative compound. Suitable draw-boxes are provided at intervals. The high-tension joints are of the Raworth-Geipel patent type, which have many advantages over the ordinary vulcanised rubber joints; the joints, being mechanical, are easily made and can be inspected by merely lifting off the cover; while the cable can easily be disconnected for testing. The transformer chambers are equipped with Mordey Victoria transformers of the 18 kilowatt size.

The principal streets are lighted by means of Brush arc lamps fitted to ornamental posts, and worked from machines independently of the private supply. The bye-streets are to be lighted by incandescence lamps, which are cut in by means of Lobley's patent automatic switch when the arc light circuits are started, so that the whole of the streets are lighted simultaneously by merely switching on at the generating station.

There are two Brush series dynamos for the arc lighting, each capable of developing 12,500 watts at 8 ampères, running at 900 revolutions per minute. They are fitted with all the latest improvements.

The arc light machines are driven by two vertical tandem type engines, having cylinders 6 inches by 10 inches by 8 inches stroke, running at 200 revolutions per minute. They are fitted with steam stop valves, continuous lubricating arrangements, grooved fly-wheels, and Acme governors. Separate cotton ropes are used for driving.

The arc light circuit switchboard is of polished oak, fitted with hook and stirrup connections for two dynamos and one circuit, it is also fitted with a suitable ammeter, provision being made on the board for extensions.

The arc light main consists of a cable highly insulated with vulcanised rubber, protected by prepared tape, compounded and drawn into cast-iron pipes. Geipel's patent telescopic stout boxes, constructed entirely of cast-iron, are used for these mains.

METALLIC INTERSTITIAL ELECTROLYSIS.

An important development of the medical uses of electricity was described by Dr. Augustin H. Goelet in a lecture delivered by him at the West Side German Clinic, New York, recently. The process described is based upon Dr. Gautier's method of electro-chemical medication, consisting of the application of iodide of potassium, which is decomposed by the action of the current, and either iodine or potassium is liberated according to the pole upon which it is employed.

This method was applied with considerable success to the treatment of a number of diseases of the skin and mucous membrane, including some forms of urethral trouble. The electrode used was platinum, in rod or other suitable shape, wrapped with absorbent cotton and dipped into a solution of iodide of potassium. An advance upon this method was made by Prochownich who used a bare copper sound as an electrode, thus enhancing the germicidal properties of the positive pole. Following this up Gautier has adopted the method called metallic interstitial electrolysis, in which the action depends upon the electro-chemical decomposition of the metal employed as the positive electrode. "Instead of a chemical decomposition of the tissues in contact with the electrode, which occurs when a non-attackable metal, such as platinum or gold, or carbon, is employed, the metal is acted upon and the formation of an oxy-chloride of copper is the result." An insoluble copper salt of an apple green colour is formed and is driven into the surrounding tissues by cataphoric action. That it does thus pass inwards was proved by experiments upon the uteri of rabbits, wherein the tissues were found to show the characteristic apple green stain for a considerable distance from the electrode. "One great advantage claimed for this method of application is that the usual caustic action upon the tissues, which occurs when non-attackable electrodes are employed, is avoided when attackable metals are employed, since the action takes place upon the metal instead of upon the tissues."

Dr. Goelet has further developed the process by using other oxidisable metals, more particularly zinc, and his experience of it, now extending over a period of a year, "satisfactorily demonstrates the usefulness of this method of application." The method has been found useful in cases of uterine hemorrhage, endometritis, urethritis, ulcerating surfaces, &c. "The electro-chemical decomposition of a zinc electrode by the positive pole results in the formation of an oxy-chloride of zinc, which cannot be attained in any other way. With a strong current it is capable of extensive destructive action." By moderating the strength of the current, and limiting the duration of the application, this destructive action is avoided. In fact, the result is then only a softening of the tissues, and sloughing does not occur. This action, continues Dr. Goelet, "I have applied to the softening of fibroid and keloid growths, in cases where the negative pole would be contra-indicated, and also in conditions of sclerosis, with very gratifying results."

It seems to us that in metallic interstitial electrolysis we have a very ingenious and interesting combination of electrical and chemical action which is well worthy of the closest attention of medical men, especially those of them who devote their attention mainly to diseases of the skin.

INCANDESCENT LAMP LITIGATION IN AMERICA.

A few weeks ago we briefly noticed two recent cases which had been decided in the United States, in both of which the Edison Electric Company were the complainants. In one of these, viz., an appeal against the Buckeye Electric Company, the complainant company was for a second time unsuccessful by reason of a certain amendment which had been introduced into the Patent Office, dated December 18th, 1883. Owing to this amendment giving an incorrect date, and that the proceeding was taken under a mistaken view, the limit of the existence of the patent became restricted to that of a British patent of 14 years, which period has already expired. This amendment was, however, expunged on March 13th, 1893. Since the said appeal was heard a case came on against the Universal Electric Company, the argument used by this company being apparently the same as in the Buckeye cases. The result, however, was not the same, it being held that since these defendants began business as infringers and made further investments after the revocation of the amendment, filed in March, 1893, the conditions were different and, therefore, the judgment must be different also. On August 1st, a further case was heard at Chicago, the defendants being the Star Electric Lamp Company, D. J. Kennedy, A. S. Terry, and F. S. Terry, the complainants being, as usual, the Edison Electric Company. Judge Seaman, who heard and decided the case, considered that if analogous situations were shown

to exist here as existed in the case of the Universal Electric Company the same ruling should be arrived at. The legal existence of the Star Company dates only from March 18th, 1893, and it is thus subsequent to the cancelling of the amendment of the Edison patent. Hence, on the well-settled principles laid down in the case against the Universal Electric Company, it would be impossible to grant the estopel demanded by the defendants. But the defendants maintain that the Star Company is merely an outgrowth and continuation of another corporation called the Sunbeam Incandescent Lamp Company, the new concern having the same property, officers, and stockholders—being in fact the same undertaking under another name. It appears, however, that the Sunbeam Company has had an extensive legal experience with the Edison Company, and as a result an agreement was arrived at between the two companies on May 17th, 1893, whereby the complainants waved all costs and damages, the defendants being allowed to continue manufacture under certain conditions pending a final injunction. This final injunction was granted October 2nd, 1893. The defendants claim that the agreement with the Edison Company was entered into on the understanding that the life of the patent would terminate on November 10th, 1893, although it is admitted that the complainants then asserted that they had a right to monopoly for 17 years from the date of the patent. It is significant also that, until lately no claim to this estopel has been made by the defendants. The Star Company and the Sunbeam Company have, besides, separate corporate entities; but even if the former be virtually the same undertaking as the latter, it cannot expect to take the benefits of the old without the attendant burdens. An injunction was therefore granted against all the defendants according to the prayer of the Bill.

THE ACTION OF ALTERNATING CURRENTS ON DIELECTRICS.

By G. L. ADDENBROOKE.

I see Prof. Silvanus Thompson has revived the statement that alternating currents have less action on dielectrics than have continuous ones for equivalent mean pressures; this point a short article in your number of 31st ult. attempts to refute by referring to the $\frac{a}{\sqrt{2}}$ point. The arrangement, however, appears to me to be beside the mark; if you will turn to your own columns for the autumn of 1887, or the spring of 1888, you will find one or possibly two articles by me referring to the subject, one particularly on shocks from alternating currents. I am away from my papers at present and cannot refer to the articles, but I clearly stated then, and I have reiterated it at the Institute here and also at the Institute of Electrical Engineers in New York, that after considerable experience and opportunities of observation, so far as I am aware, there is no experimental evidence at present to show that the influence of equivalent alternating currents on dielectrics is greater than continuous, or that they have greater penetrative power, so long as the alternating current is anywhere near a sine curve, in fact, there are several directly negative facts to such assertions which were pointed out by me at the time. The first is the sparking distance is greater for a continuous current than for an alternating, and that for a given mean voltage a greater arc can be drawn with a continuous current than with an alternating. The third and most important reason in my mind, however, is entirely ignored in your article.

Those who are accustomed to testing cables are perfectly well acquainted with the fact that a dielectric will not take its full strain until it has been submitted to electrification for quite a considerable time—measured by several minutes. Even to charge a cable for a condenser reading, it is usual to keep the charging key down for two or three seconds. It is fairly clear from this that with an alternating current of, say, 100 periods per second, which means two opposite maxima in this time, the period of maximum again during each of these phases only lasting a portion of the phase, say, $\frac{1}{3}$rd for example, the period of voltage above the mean cannot last for more than $\frac{1}{600}$th second, and often would be less than this figure.

It may be argued that this rapid alteration in the polarisation of the molecules tends to disintegrate the material, but of this I am unaware of any evidence so far, though it seems not altogether impossible. On the other hand, we have fairly good evidence from the behaviour of ordinary Leyden jars, when charged to a too high potential, that the discharge and rupture of the dielectric is seldom a sudden effect, the jar or sheet of glass usually shows evidence of some time action, though it may be short, before the rupturing discharge actually penetrates the plate or jar.

The point which you mention as to the sparking of the electrostatic voltmeter at 20,000 volts alternating seems to me, on the evidence presented, to have been probably a resonance effect. As regards makers testing cables up to 1,600 volts alternating for a 2,000 continuous specification, I should imagine that it is rather due to the astuteness of makers in subjecting their cables to as little unnecessary strain as possible than because they have any direct evidence to show that alternating currents are more deleterious than continuous, at any rate, if they have, this would be a good opportunity for them to bring it forward.

There is the further point that a badly constructed alternator may give an extraordinarily high maximum for a very short portion of its period and next to no E.M.F. during the rest; in that case it is quite possible that the effect on dielectrics would be more deleterious than that of a continuous current machine. It is usually small machines, which cannot often be very perfectly designed, which give these great differences in voltage, and this is the class of machine manufacturers would be likely to employ for testing purposes.

AN IMPROVED PRIMARY BATTERY.

We had the pleasure on Monday last of making a short journey on the Thames in the electric launch *Velvoca*, the prime mover of which is a primary battery constructed according to the patents of Mr. H. T. Barnett; 30 lbs. is the weight of each cell, and 48 cells can propel the launch at five miles per hour for 10 hours carrying 12 persons comfortably.

This performance seems to us exceedingly good for a battery weighing only 14 cwt. But the chief interest centres in the battery itself which acts remarkably well, and seems to be designed on good engineering principles.

History repeats itself often, for, as every electrician knows, the primary battery and electromotor were applied by Jacobi for propelling a boat on the Neva some 50 years ago. The failure of this boat was due to the primitive design of his motor, but now that we have motors which convert 90 per cent. of the electrical energy given to them into motive power, the energy of the primary battery can be made the most of, and success reasonably expected.

The expense per horse-power hour is apparently great, but when everything is balanced up for and against the primary battery, and other prime movers, the question of expense when applied to the case of an electric launch may not prove to be an important matter.

In this brief notice we cannot go into details, but next week we shall do so fully. Suffice it to say the battery is an improved Smee type in which the hydrogen is thrown off by fine filaments of carbon attached to the negative plates.

The inventor boldly accepts the principle "that a low electromotive force, or rather terminal pressure, coupled with constancy at that low pressure, and with extreme simplicity, is preferable to high terminal pressure, short constancy, and the complications introduced by chemical depolarisers."

In this battery zinc simply displaces hydrogen, so that although the plates of the battery are carbon and zinc in dilute sulphuric acid and water, the terminal pressure on closed circuit is that due to a zinc hydrogen couple, and not that due to a zinc carbon couple, and so we get only half a volt per cell, but this half volt is remarkably constant.

The results of the inventor's experiments and Prof. Jamieson's tests are before us and we shall discuss them in our next issue.

The run of the boat at the trip we attended lasted only about two hours, so that personally we cannot vouch for the ten hours' capacity of the battery on the *Velvoca*.

THE SPERRY ELECTRIC BRAKE.

PROBABLY the most important improvement in braking apparatus that has been made since the introduction of the air brake, is the electric brake, which has recently been perfected by E. A. Sperry, of the Sperry Electric Railway Company, Cleveland. This brake, says the *Street Railway Review*, may now be considered as beyond the experimental stage, which is more than can be said in regard to other electric brakes for use on trolley roads, with the exception of the expedient in use at Sioux City, of turning the motor into a generator. The Sperry brake has been in practical service for some time, at Cleveland, Philadelphia, and Waterbury, Conn. One has just been put on the Twenty-second Street electric line of Chicago, by R. L. Caldwell, who represents the Sperry Company.

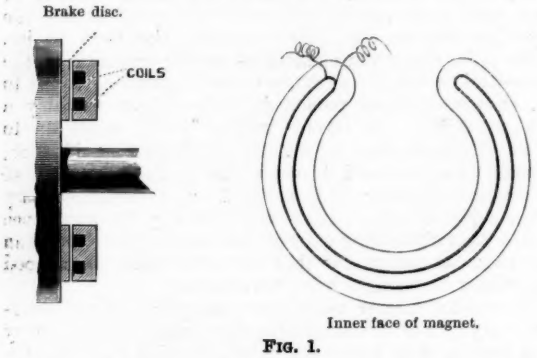


FIG. 1.

The Sperry brake consists, in brief, of a magnetic clutch, operated by current furnished by the motor acting as a generator. To provide for the electric brake, one wheel on each axle is cast with a flat disc, which is polished on its surface and against which the magnet acts. The magnet is C shaped and has an internal coil, as shown in the engraving. It is made C shaped and not a ring so that it can be taken off the axle.

The method of operation is as follows: Both brake and controller are worked by the same handle. Suppose a car to be running with the current on and a stop is to be made, the handle is thrown to the "off" position, and when it strikes the "off" position it throws a switch, which cuts off the trolley current and makes connections, so that when the handle is put on the first point of the controller, the motor, brake magnets, and about eighteen ohms resistance, are placed in series with each other. The motor "builds up" immediately, and sends a current through the brake magnets and resistance. The less the resistance in circuit the harder the brake is applied, so that this can be regulated entirely by the controller handle. When the controller is connected as a brake, and is thrown back to the "off" position, it trips a switch, which throws in the trolley current and makes it again an ordinary controller. In other words, every other time the handle is on the "off" position it becomes wired as a brake and every other time as a controller. The simplicity and practical efficiency of this arrangement is too obvious to need comment.

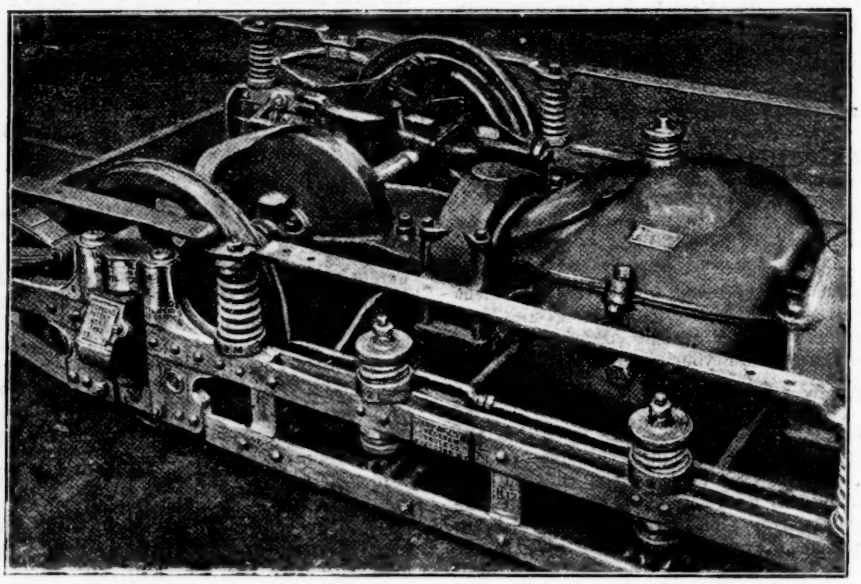


FIG. 2.

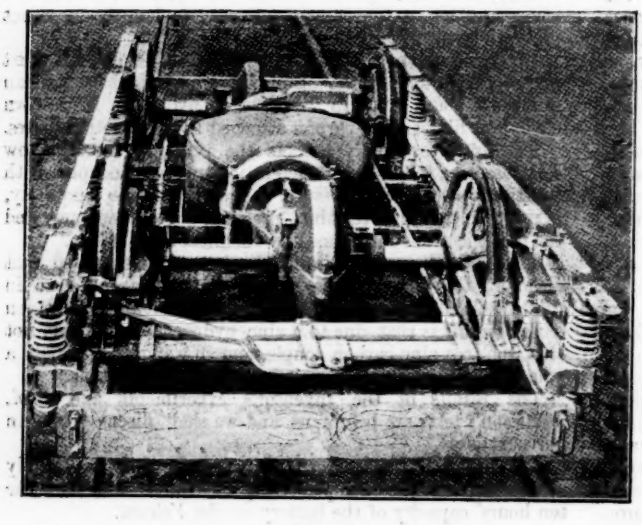


FIG. 3.

With this brake it is impossible to slip the wheels for more than an instant, as the moment the wheels stop the motor stops generating current. The stops made with this brake are remarkably quick and smooth, as the correct braking principle is applied, of making the hardest application at high speed and automatically reducing it as the speed falls.

The brake is very simple and entirely independent of the trolley current. It introduces very little additional complication in the wiring of a car, as the same rheostat is used in the brake circuit and for starting. The rheostat required is a little higher resistance than the usual one, as it requires about 18 ohms to cut the current down enough to apply the brake easily. As the brake is operated with so small a cur-

rent there is very little strain on the motor or rheostat. In regard to the wear on the magnet and disc, there is reason to believe that it will be very slight, as a large part of the breaking force is magnetism and not friction, and the surfaces have graphite lubrication. The controller box, which is the ordinary size, has an indicator which shows whether the switch is turned to the controller or brake positions. The brake is made for every day use, and is as thoroughly practical a device as the modern railway motor. It can make emergency stops with a minimum of shock, and the service stops are remarkably quick and smooth.

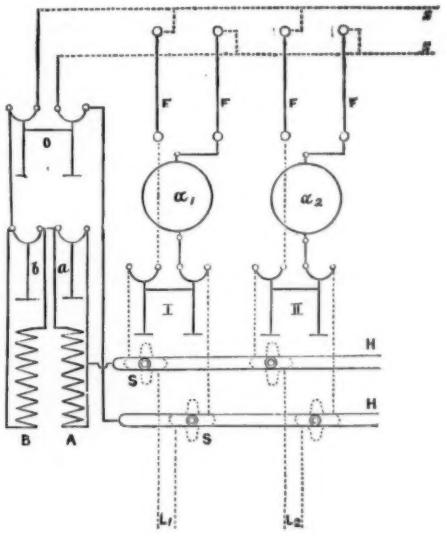
THE PARALLEL WORKING OF ALTERNATORS.*

By GISBERT KAPP.

Parallel working with alternators has of late years become almost the rule at central stations. The employment of machines working independently, each of which supplies a circuit, or a group of circuits, with current, has been found too complicated, and the machines in general work at greater disadvantage than if in parallel connection. It was believed at first that certain types of alternators could work in parallel connection, and others not. But it has been found in practice that all good modern alternators can be thus grouped, and that even though differences exist in this respect in the behaviour of different types, they are by no means of such importance that they can exert an essential influence upon the working. Where difficulties occur in parallel working, they are derived not from the alternators, but from their driving machines. A condition for good running is that the machine should have a rotary motion as constant as possible, and have a sufficient fly-wheel, in order that the angular velocity may remain constant. If this is not the case, there occurs in the various alternators in parallel arrangement a to-and-fro undulation of currents which tends to compensate the fluctuations of power, and it may happen that these fluctuations are great enough to throw the machines out of step.

These points are now well known to constructors, and there is no difficulty in obtaining from good establishments steam alternators which work faultlessly in parallel connection. The insertion is effected whilst observing the synchronising lamps at the point of time when the machine to be introduced runs temporarily in step. Instead of lamps there may be used voltmeters or acoustic signals, but some experience is always needed, and rather close attention, in order to seize the right moment for putting in the switch. The difficulty of this is felt especially when the compensating masses in the machine are relatively small. In such a case it may happen that in adjusting the speed it varies so quickly, that there is scarcely time for observing the moment of synchronous movement, and the operation must be repeated until we at length can catch the correct rapidity and effect the insertion. This often involves a considerable loss of time, which may be very inconvenient when a new machine has to be quickly inserted. Besides the loss of time, it is essentially bad policy to make the success of an important operation depend on the more or less acute observation of the attendant at the switchboard. In order to avoid the difficulties of these two points, I devised at the Bristol central station the arrangement shown in the diagram, the object of which is to effect the insertion of a new machine expeditiously and without any perceptible shock, and without requiring any especial dexterity from the attendant at the switchboard. The apparatus was set up at the beginning of the year, and acts in a manner quite free from faults. L_1, L_2, are the alternating current leads coming from the alternators. They can be connected with the collecting bars, *s s*, by means of the double switches, I, II, the ammeters, a_1, a_2, and the fuse wires, F.

Besides these omnibus bars there are at the front of the switchboard two auxiliary bars, H, H, which can be connected with any pair of leads by means of plugs. In all, the switchboard is adapted for five machines though there are only two plugs, so that a direct parallel insertion of two or more machines to the auxiliary bars is not possible. One of the auxiliary bars is connected with the corresponding collecting bar by two coils, A, B, and the switch, O, whilst the other auxiliary bar is directly connected with the corresponding collecting bar by means of the switch, O. The choking coils (Hedgehog transformer, each, however, only with one coil), are so arranged as to their windings and their



weight of iron, that at the normal pressure of the machine rather less than the normal machine current can pass through. The switches, *a* and *b*, serve for separately short-circuiting the choking coils, *i.e.*, throwing them out of action.

The manner of using the apparatus is as follows:—Supposing the machine connected with L_2 is at work, and that of L_1 is to be connected. All the switches to the left of II are at first open. The machine I is excited and allowed to run, whilst a plug is inserted at S, and the double switch, O, is closed. As soon as the machine approaches its correct speed, the current flowing through the choking coils (limited in its strength) begins to draw gently the machine into step. It runs, therefore, in time, but not yet necessarily in the correct phase. The switch, *a*, is now closed, which gives a slight shock to the current, bringing the machine nearer to the correct phase. When the switch, *b*, is closed there again occurs a slight shock, which brings the machine exactly into the right phase. The switch, I, is then closed, the three switches to the left are opened and the plugs are withdrawn, whereby the apparatus is again ready for further use.

The introduction of a machine can be effected, in the rule, within 20 seconds by means of this apparatus, requiring no precaution beyond observing the right order of succession in closing the switches. The choking coils do not need to be large, as they are in action each time only for a few seconds, and are therefore in no danger of heating. A similar method is in use by the General Electric Company, in America. But instead of the switches, *a*, *b*, there is used a strong copper casing which (as in Thomson's welding transformers) is pushed upon the coil, so as to diminish its self-induction.

* *Electrotechnische Zeitschrift.*

MONO-PHASE MOTORS.

By W. B. ESSON.

In a leading article on "Polyphase Work" in the Electrical Review of August 3rd, it is regretted that tests of mono-phase motors were not at the writer's disposal for comparison with results obtained from polyphase motors. The following tables give the results of tests made by me in October and November of last year, and may possibly prove of interest to your readers, as very little, if anything, on this matter has hitherto been published.

The motors were constructed by Messrs. Brown, Boveri and Co., of Baden, Switzerland, and were of 2 B.H.P., 1 B.H.P., and ¼ B.H.P., respectively, being designed for a mean difference of potentials of 100 volts, and for a frequency of 80 complete cycles per second. It will be seen that they were of such sizes as might be demanded for use in small workshops or for domestic purposes. They were each fed from transformers of ordinary construction, reducing from 2,000 to 100 volts.

The method of testing was as follows :—The mono-phase motor, M, was belt-coupled to a small direct current dynamo, D. The field of D being separately excited, the power required to be given to the armature of D to drive both M and D at full speed was measured, D of course running as a motor, and the alternate circuit disconnected. This, *minus* the C^2 R loss in the armature of D was taken to be the mechanical power loss in the system, in friction of journals, hysteresis in direct current armature, &c. Call the amount F. The alternate circuit being closed for the tests, M now drives the system, the electric power taken out of the armature of D working as a dynamo being measured, and its field excited by the same current as when running as a motor, it spun the system round at the same speed idle. The watts measured at the terminals of D *plus* the C^2 R loss in the armature of D *plus* the amount F, previously mentioned, is credited as the power given out by M. It will be observed that this may differ, but by a very minute quantity, from the power which would be measured by a Prony brake. The power spent in friction of M's bearings is here credited as power obtained, while with a Prony brake this would not be the case. However, a series of Prony brake tests made by Dr. W. E. Sumpner on the 1 H.P. motor accords with my tests so completely that the difference between the two sets of results are quite negligible.

The instruments used were a Cardew voltmeter, Siemens dynamometers, and a wattmeter. Every precaution was taken to prevent belt slip while the tests were in progress, but it will be seen that, consequent on the method of testing employed, any power absorbed due to slipping would be against the motor. The load was varied by altering the resistance in the circuit of D in the usual way. The volts were maintained at 100, and the frequency at 80 throughout.

The results are given in the tables below :—

TABLE I.—2 HORSE-POWER MOTOR.

Amps.	Absorbed.		Power factor.	Power given out in watts.	Revs. per minute.	Actual efficiency per cent.	Apparent efficiency per cent.
	Watts actual.	Watts apparent.					
30·0	1,848	3,000	·616	0	0	starting	starting
12·7	252	1,270	·200	0	1,570	running	idle
14·5	520	1,450	·380	200	1,550	55 8	20 0
18 0	1,040	1,800	·557	687	1,520	66·0	38·1
24 5	1,630	2,450	·665	1,100	1,500	67·5	44·9
30·5	2,050	3,050	·672	1,400	1,490	68·3	45 9
51·2	2,150	3,120	·690	1,520	1,480	70·7	48·6

TABLE II.—1 HORSE-POWER MOTOR.

Amps.	Absorbed.		Power factor.	Power given out in watts.	Revs. per minute.	Actual efficiency per cent.	Apparent efficiency per cent.
	Watts actual.	Watts apparent.					
22·0	1,125	2,200	·511	0	0	starting	starting
8·48	176·4	848	·210	0	1,560	running	idle
10 0	364	1,000	·364	213	1,540	58·5	21·3
12·45	706	1,245	·567	500	1,520	70·8	40·18
16·7	1,109	1,670	·663	800	1,490	72·1	48 00

TABLE III.—¼ HORSE-POWER MOTOR.

Amps.	Absorbed.		Power factor.	Power given out in watts.	Revs. per minute.	Actual efficiency per cent.	Apparent efficiency per cent.
	Watts actual.	Watts apparent					
36·5	2,188	3,285	·666	0	0	starting	starting
3·0	128	300	·430	0	2,330	running	idle.
5·5	343	550	·620	245	2,280	71·4	44·6

N.B.—The starting current for the ¼ H.P. was taken at 90 volts.

The first column in the tables gives the ampères as measured on the dynamometer, the second the actual watts absorbed in the alternate current circuit as measured by the wattmeter. The third column gives the *apparent* watts found by multiplying the current by the Cardew voltmeter indications. The power factor in the fourth column is the ratio of the *real* to the *apparent* watts, and both actual and apparent efficiencies are given in the last two columns, the latter being of course the smaller, since the apparent watts given to the machine are greater than the real watts.

Each motor armature is wound with two sets of coils, one being used as an auxiliary for starting, the other being the working set. The motors start from rest as di-phase motors, the current being split, and the portion through the auxiliary coils thrown out of phase with the portion going through the working coils by means of a condenser. When the full speed is attained a two-way switch is thrown over, and the auxiliary coils cut out, the motor continuing to work as a mono-phase motor, with the current going through the working set of coils only.

Using a loose pulley and striking gear there need be no difficulty in getting the motor to start. The condenser can be placed on a shelf close by, and the manipulation of the switch is quite easy. Comparing the trouble of starting with that of a small gas engine, the mono-phase motor is much to be preferred; but it will be seen that the starting current is very high, while the power factor is very low. These attributes constitute a serious hindrance to their general use, both from the point of view of user and station engineer. It may be said that small motors would be always more or less fully loaded; but even at full load the power factor is less than with good transformers on open secondaries, which means working station machinery seriously underloaded. Manifestly, there is still room for a good deal of improvement in mono-phase motors.

ELEMENTARY THEORY OF THE INDUCTION ALTERNATING MOTOR.

By RANKIN KENNEDY.

II.

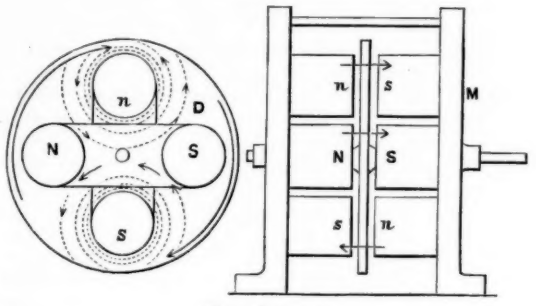
In the last paper I considered the elementary theory of the single-phase induction motor, and investigated the reason why it is not self-starting without some device being added to it for that purpose. We also found why it runs on when given a start. When stationary, the disc with its induced currents is in equilibrium, but if in motion, the paths of the current are carried round into a position where the magnetic flow propels the disc with its induced currents; we also saw how the lag in time between the current set up and the magnetic flow which set it up, allowed time for the current to be carried round into a motor position in time to coincide with the following magnetic flow.

I now come to a class of motors in which we have two sets of poles and two currents, purposely made the one to lag behind the other by a quarter of a period, so that when the one is at its maximum strength, the other is at its minimum or zero value.

By the use of two currents in this way, we are able to make an induction motor start off from a state of rest with great torque. The induced current set up by the one set of poles is attracted and repelled by the magnetic flow of the other set, which being energised by a current coming a quarter of a period behind their magnetic flow, coincides with the current flow induced by the first set, so that the disc is propelled round to bring the current concentric with the second set.

In figs. 3 and 4 this class of motor is illustrated diagrammatically. Imagine a copper disc mounted on a spindle and between two sets of field magnets, N, S, energised by one current, *n*, *s*, energised by the other; referring to fig. 4, *n*, *s*, have just been energised by a wave of current which set up the induced currents in the disc, represented by the concentric dotted lines, the magnetic flow from *n*, *s*, is falling to zero; but the magnetic flow in N, S, is now rising to a

maximum, and a time arrives at which the currents in the disc are a maximum, and the magnetic flow from N, S, is a maximum, while the flow in *n*, *s*, is zero, hence the disc is pulled round to bring the current flow concentric with N, S. Then N, S, set up an induced current in the disc, which in turn coincides with the next maximum magnetic flow from *n*, *s*, this propels the disc again to bring the current and magnets concentric.



Figs. 3 and 4.

Thus we see that the currents set up by the one set of poles are acted upon motively by the other set, because the one set of poles are at a maximum flow when the other set are at zero, and the currents induced by one set are at a maximum at the same instant that the magnetic flow of the other set is at a maximum, and thus the motor starts with considerable torque from a state of rest if we have two sets of poles energised by two currents having a difference of phase of one quarter of a period.

Now, if after this motor has been started one of the two currents is entirely cut off, the disc will still run on, and, what is more surprising, it will exert as much power as it did with the two currents, or rather, to speak more accurately, it will run at a higher speed when at its maximum torque. This fact leads to a most important conclusion, namely, that the two currents are of no advantage except as an aid to starting; and if we could start the single-phase motor with full torque by any means it would have the advantage in simplicity and direct applicability to present circuits.

Mr. C. E. L. Brown has devised several methods of starting the single-phase motors described in our first paper, but what the actual torque obtained by the best of his methods is I cannot say, as actual independent tests are not available.

The shielded pole method described in our first paper is due to Prof. Elihu Thomson, and does not give more torque than that necessary for a start.

The two-phase motor has still the paramount advantage of starting without any extraordinary devices, and that, too, against considerable torque. And when it is taken into consideration that motors are only used to any extent in isolated plants, where the generator, the mains, and everything else can be erected for two-phase working, the two-phase motor is likely to hold the field in cases where absolutely no commutation is desirable.

Immediately we introduce the commutator, even if only for starting purposes, then the motor is on a level with the ordinary continuous current motor, it is the entire absence of the commutator which is the sole recommendation for the alternating motor. Accept a commutator and the ordinary motor is ready to do the work.

It will be quite easy to apply this elementary theory to a three-phase motor, and at a future time we hope to describe actual disc motors of the types shown in these diagrams, which are to be taken merely as aids to understanding the principles and not as the best designs for construction.

OBITUARY.

Prof. Von Helmholtz.

The whole scientific world will be profoundly moved by the death of Prof. Von Helmholtz. His country, remarkable as it is for great old men, will be none the less impressed by an event which has robbed it of one of its grandest figures. Prof. Von Helmholtz was a man in whom all nations gloried. His attainments were cosmopolitan, his thoughts were for all nations; hence the whole world deplores his loss. He was, moreover, a patriot and a German; hence his countrymen mourn at his decease. In many respects Von Helmholtz was among the most remarkable men that ever lived. He had accomplished enough to invest half-a-dozen men with fame. Yet we are told that he remained, in spite of hero worship and adulation, a man simple in his habits, and participating in none of the ordinary pleasures of the world. Mr. Dawson, who in his recent book on Germany and the Germans gives many a delightful sketch of German professors, speaks of him as almost a recluse, and one of the most inaccessible men in Germany. It is true that in later years he became more and more confined to his laboratory and his study, but when he emerged from them he delighted the world with his lucidity of thought and his felicity of expression. Those of us who had the pleasure and privilege of hearing him at the Edinburgh meeting of the British Association are not likely to soon forget his breadth of thought and the charm of his manner.

It is difficult to give briefly an adequate notion of what he has done. When we say that for well nigh 50 years he has laboured and wrought in the field of physics, it is enough to show that a mere cataloguing of what he achieved is beyond the scope of a newspaper article.

In giving the bare facts of his life and birth, it is enough to say that Herman Ludwig Ferdinand von Helmholtz was born at Potsdam in 1821. His father was a teacher of German in the Gymnasium. Englishmen may feel a sense of pride in the fact that his mother was an Englishwoman. For some time he studied medicine in the Military Institute at Berlin, and became attached to the staff of one of the public hospitals there; he afterwards became an army surgeon. It was during the discharge of his duties as surgeon that he prosecuted many of his studies in physics. The field of his labours, however, soon widened, and greater scope was given to his speculations, for at the age of 27 he was appointed assistant in the Anatomical Museum of Berlin, from whence, in the following year, he moved to become Professor of Physiology at Königsberg. In 1856 he accepted the position of Professor of Anatomy and Physiology at Bonn, and three years later he was occupying a similar position in the University of Heidelberg. During these wanderings he did a great part of his physiological work, but his more mature work was accomplished as Professor of Philosophy in the Berlin University, a position which he held up to a few years ago, when he retired to become the head of the Reichanstalt.

Although Prof. Von Helmholtz has done good work in electricity, more especially with reference to electric measurements, his fame rests chiefly on what he has accomplished in other branches of physics. His remarkable pamphlet on the "Conservation of Energy," written when he was quite a young man, first attracted the attention of scientific men. The essay was mainly devoted to a criticism of existing theories, the theory mostly associated with Stahl being dissected with merciless severity. Naturally the essay evoked much discussion, and the feeling of scientific men ran high. Tyndall who, likely enough, was in Germany when it was published, with his usual keenness at once appreciated its power, and became the English translator of it.

It would need a more skilled pen than the writer's to speak with adequate appreciation of Helmholtz's work on optics and sound. The science of the subjects was practically in a state of chaos when he came to handle the matter; he evolved a theory of sound which ranks as one of his greatest accomplishments. His "Theory of the Impressions of Sound" was published in 1862, but 13 years elapsed before his great work appeared on "Sensations of Tone as a Physiological Basis for the Theory of Music." In the interregnum, however, he had delighted numerous audiences by his popular treatment of scientific subjects. These popular lectures were translated into English by Dr. E. Atkinson in 1872, a second series appearing in 1881.

Perhaps the most remarkable discoveries of Helmholtz's, and one that has unquestionably proved an immense advantage to the human race, is the ophthalmoscope. By this instrument Helmholtz substituted direct observation for conjectural methods. According to an appreciative account of his life, we learn that this discovery came about in a some-

what curious manner. "Having to lecture on Brucke's theory of ocular illumination, he was casting about in his mind for a tangible explanation, when the idea struck him. He was well aware of the difficulties under which oculists laboured in the treatment of conditions known as amaurosis, and set about constructing a rough instrument which should overcome them. In a week he had seen for the first time a living retina."

It is doubtful whether any scientific man has been more prolific in the publication of scientific papers than Von Helmholtz. In fact, all his work bears evidence of the most extraordinary fertility. As an instance, we may mention that in the Index of the Royal Society over 100 papers by Helmholtz are classified. In these, physiological, mechanical and mathematical questions are discussed with a grasp and insight that is astonishing. For his achievements in, and services to science, he was awarded the Copley Medal of the Royal Society in 1873, and some years later a title of nobility was conferred upon him by the German Emperor. Orders, decorations and degrees flowed in from all countries, and from almost every learned society. Monarchs vied with scientists in doing honour to his wisdom, and in honouring him they honoured themselves.

CORRESPONDENCE.

The Magnetised Head Cap.

Not content with the discomfiture of the enemy in our midst, the Electrical Review, like the watchman on the tower, warns us of the approach of a fresh danger. Your opinions of the "hypnotherapeutic department" of La Charité, and the marvels of the magnetised head cap must be shared by all who give the subject a moment's reasonable thought. As a matter of fact, science knows nothing of the action of magnets on the human body, excepting the apparent absence of action. It will be remembered that in the striking, though not perhaps absolutely conclusive, experiments to which you refer, that with a magnet, the weight of which was 5,000 lbs., and with a magnetic field, of which the intensity was 2,500 C.G.S. lines to the square centimetre, it was shown that with a "subject" lying between the poles of such a magnet, neither common sensation nor sphygmographic tracings, nor respiration, nor knee jerk were perceptibly influenced. The same experiments showed that in a magnetic field of 5,000 C.G.S. lines to the square centimetre, no effect was observable under the microscope on dry hœmoglobin or on fresh blood; that living ciliated epithelium showed no change in its movements, and that when the web of the frog's foot was introduced between the poles, not the least influence on the blood cells or circulation was visible, and all this in a magnetic field so strong that the microscope had to be clamped down to the table. The experimenters therefore felt themselves justified in considering that if such magnets as are used in medicine have any effect at all, their action must be purely psychical, and that therefore a wooden "magnet" might do as well.

So far as Dr. Luys himself is concerned, everyone must recognise in him a man who has done good, conscientious, even brilliant work. With all his eminence, however, as a cerebral anatomist and physiologist, it is admitted that he has at times shown himself eagerly credulous in the adoption of novel and improbable hypotheses. In a recent instance, where he appears to have considered that drugs in hermetically sealed tubes, if applied to the head or neck during the hypnotic sleep, would produce the same effects as if ingested, if it was decided by the French Academy of Medicine that he had been egregiously deceived, it was at the same time shown that he had unconsciously "suggested" to the patient the effects which he wished to produce.

This so-called "magnetic transference of cerebral activity" finds, as you say, a ready explanation in the acknowledged fact of hypnotic suggestion. This being so, it is interesting to remember, in connection with the "magnetic transference of lunacy," that lunatics are not, as a rule, susceptible to hypnotism, inasmuch as they are incapable of that willing and sustained attention which is one of the necessary conditions.

W. S. Hedley, M.D.

Determining the Position of a Fault in a Submarine Cable between the Repairing Ship and Shore Station by the "Fall of Potential Test" when the Conductor is Not broken.

Mr. J. Rymer Jones is to be congratulated for having described the above test in the Electrical Review of last week, in a very clear, concise, and complete manner. It is also gratifying to find an electrician (so far from home) using the best system of diagrammatic illustrations, lettering, notation, and symbols, whereby any other electrician can at once comprehend the meaning of his text without effort. Figs. 1 and 3 are, however, the same as may be found at pp. 210 and 135 of Munro and Jamieson's "Pocket-Book of Electrical Rules and Tables" (Tenth Edition); but his examples in connection with fig. 3 have drawn my attention to an error in that book, where $E_2 = \frac{10,000}{a} E_1$ should be $= \frac{100,000}{a} E_1$ (or standard cells). Mr. Jones's modification of Sir Wm. Thomson's capacity test is at once evident from the figure, description, and formulæ on pages 164 and 165 of Munro and Jamieson's pocket-book, for it is shown there that the fall of potential on the one side multiplied by the capacity on that side, is equal to the fall of potential on the other side multiplied by the other capacity.

or $V_1 K_1 = V_2 K_2$,
where $V_1 V_2$ are the potentials in volts,
and $K_1 K_2$ are the capacities in microfarads.

Both these tests are simply Wheatstone bridge "null" methods, wherein condensers are used in one pair of the arms of the bridge instead of resistances. With slide resistances on board ship we never found any difficulty (since 1873, *i.e.*, when Clark cells were first in the market), of ascertaining the potential of the free end of a faulty cable by the "null" method, described by Mr. Jones in connection with his fig. 3. The Clark cells were put on where his battery, *b*, is shown (*i.e.*, through 100,000 ohms), and the free end of the faulty cable was brought *intermittently* into contact with the movable point, *c*, on the slides, through the marine galvanometer and a tapping key, until a balance was found between the potential of the end of the cable and a point on the slides.

It would be interesting to know whether the plan illustrated by fig. 2 is really more expeditious and reliable on board ship, or on shore, than the old "null" method to which I have just referred? I will try them both when I get back to Glasgow. With Messrs. Ayrton & Mather's modification of the D'Arsonval galvanometer, or with Herbert W. Sullivan's new "dead-beat marine pattern" (as just brought out by Messrs. Elliott Bros.), such tests may be much more conveniently carried out on board ship than with the "old ironclad," &c., on shore, or with the astatic "mirror" galvanometer.

Andrew Jamieson.

Electrical Engineering Laboratory,
The Glasgow and West of Scotland Technical College,
September 10th, 1894.

A Troublesome Dynamo.

A line to ask your advice. I have a shunt dynamo which sparks badly; Manchester type; output at 1,800 revolutions, 50 volts 24 ampères; number coils on armature, 60; length wire, 30 inches, diameter F.M. core, $2\frac{3}{4}$ inches × $2\frac{3}{4}$ inches long; wound, 6 inches; weight of wire, No. 20 B.W.G., $10\frac{1}{2}$ lbs. on each; S. Silk covered gauge wire on armature, No. 16 B.W.G., D.C.C.; length armature, 6 inches; diameter, 5 inches. Can it be cured by rewinding? If so, can I reduce the number of coils on armature? Please give quantities, and oblige.

Troubled.

[The sparking is due to bad design, and no rewinding would cure it. The size of the field magnets is far too small for such an armature, hence the sparking, which is due to a strong armature running in a weak field. Approximately, a machine for 50 volts and 24 ampères should have field cores $4\frac{1}{2}$ inches × $4\frac{1}{2}$ inches, and an armature wound with No. 12 B.W.G. wire at least, and in only two layers, preferably a Paccinotti armature. No. 16 wire is too thin for 24

ampères. You do not give sufficient data of your machine; you should send a fully-dimensioned sketch showing diameter of armature wound and unwound, bore of field magnet tunnel, thickness or section of metal.—Eds. Elec. Rev.]

Alternating Current Distribution.

Until Mr. Lowrie publishes the theory of the natural laws which he obeys in his transformer design, he must excuse me taking the same views as most other transformer designers. I must therefore stick to the opinion that the secondary current in his unique switch transformer is due to an alternating field which will make the pole pieces attract each other, and that, due to the presence of iron which makes the leakage path on opposite sides of the coils about equal, the repulsion and attraction between current and leakage field will very nearly counterbalance each other. The case is quite different for two solenoids without iron; then there are no pole pieces to attract each other, and the leakage field on one side of the coil will be stronger than on the other, resulting in a repulsion.

As it is part of my daily work to design transformers and superintend their manufacture and testing, Mr. Lowrie need not inform me what happens when a transformer is short-circuited; but I am glad to see that we hold the same view. He says that "when the conditions require it, the short-circuit can be made through a resistance;" I said that the result would be a burn-out, "if the resistance of the coils were not high enough to keep the current within safe limits."

As to my letter's disastrous effect on industrial development, it is my opinion that very much harm has been done, and is still being done, to the electrical trade by patentees receiving support for inventions which afterwards show themselves to be failures. I am, therefore, only too pleased to do my best to reduce the evil when an opportunity is offered, thereby supporting true progress.

S. A. Faber.

September 11th, 1894.

A Cheap Insoluble Anode.

In your leaderette last week, on "Electricity in Industrial Chemistry," you say:—"There is, *inter alia*, one great desideratum, and that is a cheap insoluble anode." . . . "When the cheap insoluble anode is found it will open a wide door to the applications of electricity in the chemical arts."

Rightly or wrongly, I am strongly under the impression that such an anode has already been found, and has, in fact, actually been available for three or four years past to those who are interested in the commercial problems of electrolysis.

For more than five years I have been continually experimenting on a class of bodies which alone would appear likely to afford the desideratum in question, viz., those metallic peroxides which are capable of acting as simple conductors of electricity. One result of my work was embodied in patent 1,246, 1890, which I took out in conjunction with Mr. A. C. Falconer. This referred to the use of "compact, coherent, and conductive peroxide of lead or lithanode, as an anode in the electrolysis of *earthy* chlorides." A further result was embodied in patent 9,799, 1892, in which means are specified for the effective use of the same anode in the electrolysis of *alkaline* chlorides. In this specification the unfounded assumption that it is impossible to electrolyse a solution of salt without producing some free acid at the anode is practically shown to be erroneous.

In answer to the suggestion that lithanode may be destroyed by traces of hydrochloric acid produced in the electrolysis of chlorides, I exhibited, at the meeting of the I.E.E., November 17th, 1892, plates of lithanode that had been used in the electrolysis of strong hydrochloric acid.

We are not likely to find a cheaper material than oxide of lead (litharge) for the manufacture of our insoluble anode, and I am not aware that anyone has ever openly traversed my statement that peroxide of lead, in the form of properly manufactured lithanode, is absolutely inattackable by electrolytic chlorine or oxygen. I say "openly," because I have heard that a report has been circulated by an interested party to the effect that lithanode does not answer as an anode in the electrolysis of solutions of salt. I do not know that it has even been experimentally tried outside of my laboratory; but I observe that the *Daily Telegraph* (*vide* "London Day by Day," September 6th) is drawing attention to "the rapid strides that electro-chemistry is making," a circumstance that would seem to imply that *some* cheap permanent anode is being utilised by an intelligent and enterprising electrical public.

I find that the same class of substances to which I have above referred will probably supply another great desideratum in commercial electrolysis, viz., a diaphragm or septum which (unlike every substance hitherto tried) is attacked neither by chlorine nor by caustic alkali.

Desmond G. FitzGerald.

COMBINED SCHEMES FOR DRAINAGE AND ELECTRIC LIGHTING AT MONMOUTH.

The following is an abstract of Messrs. Bramwell & Harris's report on this matter:—

In a report to you, dated February 26th last, we dealt with the above schemes in combination, as regards the suggestion made to you prior to this time, that water-power for driving the dynamos and the sewage pumps should be obtained from the River Wye, at the site below Wye Bridge. This suggestion we could not recommend your council to adopt.

After consideration of our report, your council passed the following resolution at their meeting of March 5th last:—

"That Messrs. Bramwell & Harris be requested to advise the corporation generally upon the proper system of drainage to be adopted, that for this purpose they inspect the town and neighbourhood, and that all the schemes submitted to the corporation be laid before Messrs. Bramwell & Harris, and that they be requested to give their report upon the whole matter, and to give the corporation their unbiassed opinion as to what, under all the circumstances, would be the best and least expensive system to adopt, and to treat the drainage and electric lighting schemes and the costs of such, so as to point out the specific savings that will be effected by combining the two."

Having already dealt with the first portion of the instructions contained in this resolution, we now deal with the final portion, and express our opinion as to "what would be the best and the least expensive sewage system to adopt," and also deal with the drainage and electric lighting schemes together, showing what, "in our opinion, would be the results, as regards first cost and working costs, and the specific savings that will be effected by combining the two."

We have sent to Monmouth and taken gaugings of the water and power available at the Old Forge Mill on the river Monnow, and surveyed the site, and from this survey have prepared a plan. The Old Forge Mill is practically the only suitable place which is available from which water-power can be obtained.

As you are aware, should your council see fit to apply for compulsory powers, they could probably purchase suitable land for sewage disposal; but this is a course we do not recommend them to adopt if it can possibly be avoided.

As regards the desirability of combining the two schemes of sewage and of electric lighting, we cannot do better than quote from our report to you of February 26th last, already referred to, where it will be found we say—

"The object of combining the two schemes is to enable the water-power at present running to waste to be satisfactorily utilised for driving the sewage pumps to pump the sewage to the irrigation land during the daytime, and also to employ that power at night for driving the electric lighting dynamos.

"Such a suggested combination is one which, on the face of it, contains many advantages, for it must be remembered that the water-power is available for day and night from year's end to year's end, and that when used for electric lighting it is only required during the hours of darkness, and that during the hours of daylight the machinery, or a large portion of it, would be lying idle unless some employment, such as that of pumping the sewage, were found for it.

"These advantages of the combination are so obvious, that we feel sure your council do not need to have them emphasised by us."

Since the above was written you have obtained a provisional order giving your council powers to supply electrical energy within your district. It must be borne in mind, however, that although it is possible the combination of the two schemes in this way would enable the whole work of the combined schemes to be carried on for a less *annual cost* than would be the case if the schemes were separate and distinct, and were carried out at separate times, yet it does not follow that it would be justifiable to establish an electric generating station for the mere purpose of causing an apparent relief of the cost of the sewage scheme. In this report, therefore, we assume that in any case the works necessary for sewering your town and disposing of the sewage have to be carried out, and we afterwards consider whether, having regard to the probability of demand for electrical energy for lighting or other purposes, it would be worth your while to spend the extra amount necessary to enable you to supply this electrical energy to customers who would pay for it, showing first the cost of carrying out the sewage scheme alone, with the annual cost of working this scheme, whether by electric or by other power, and then

showing the cost of carrying out the combined schemes and the annual cost of working the two, utilising the electrical energy for pumping the sewage during the hours when this is not required for lighting. This mode of dealing with the matter will enable your council to readily make a comparison, and they can then with full knowledge of the facts come to a determination as to whether they will proceed with the sewage scheme alone, or whether they will combine it with the electric lighting scheme.

Sewage Scheme.

Referring to our report of the 7th May last on the various competitive schemes, of which there were 22, submitted by 17 competitors, we would again remind the council that the conditions which existed when this competition was in progress, and of which alone the competitors were cognisant, have had to be considerably modified since the date of the competition, partly due to the fact that the owners of the land, or most of the land suggested by the competitors as the sites for sewage disposal, have declined to sell this land, and partly because of the objection of your corporation to either of the Chippenham sites, or to the adoption of the triangular-shaped island betwen the Old and New Monnow and the River Wye.

These modifications, which in our judgment are necessary and desirable, render it imperative that you should adopt some scheme other than either of those set out by the competitors, and it became necessary to discover some site suitable for the disposal of the sewage, which could be obtained by agreement with the owners at a reasonable price, and to devise some mode of delivering the sewage to this land and treating it there, which would be inoffensive, and therefore desirable to adopt.

As the result of a prolonged examination, seven sites in all were selected, each more or less suitable for the purpose. Since this selection you have been making inquiries with regard to these sites, but it has been found that the owners of the land in five cases have declined to sell, or the influential owners of adjacent property have expressed their intention of opposing any sewage disposal scheme on the site or sites selected, with the result that the matter has practically resolved itself into the selection of one of two alternative sites, both of them situated above the town on the banks of the River Monnow.

As no matter what site may be selected, pumping of the sewage is a necessity, owing to the contour of the surface of the area to be drained, the fact that these sites are both of them situated on the up-river side of the town, and at a level higher than the major portion of the district, is not a matter of great importance.

One of the two sites—Salts Lodge Farm—situated on the right bank of the River Monnow, and close to the Old Forge Mill, is in some slight respects more suitable than the other, which is a site on the Osbaston Road, further up the River Monnow, that is to say, further away from the district to be sewered. The owner of the Salts Lodge Farm has definitely offered to sell his property, although the price he asks is high, whereas the owner of the land on the other site, situated on the Osbaston Road, although he does not decline to sell, desires, before replying to your question upon this point, to have certain further information, information which can only be given to him by this report.

The district to be sewered, consisting of the town of Monmouth with its outlying suburbs, forms a basin, the centre of the town being practically the lowest point. The necessity for pumping, already referred to, was recognised by most of the competitors, and some of them suggested a pumping station situated at the Cattle Market, to which the sewage was to be led in stoneware pipe sewers by gravitation. The question of the exact position of the pumping station must be determined, by two principal considerations, one, the contour of the surface to be dealt with, the other, the position to which the sewage is to be pumped. Having regard to the latter consideration, and to the position of the available sites for sewage disposal, we would suggest that it would probably be better to place the pumping station at some point nearer to these than is the Cattle Market. . . . . Wherever this pumping station may be placed (and its position is a matter of detail, and for after consideration), the *total* cost of the scheme will practically be the same. To this pumping station all the sewers dealing with the whole of the district would gravitate, and deliver there into an underground tank where the sewage would be collected, this tank being sufficiently large to contain the sewage produced during the hours of darkness. In the pumping station there would be, say, three sets of pumps, each one capable of dealing with the ordinary dry weather flow of sewage, at the maximum delivery of this during a period of 24 hours. From the underground tank, and from some of the most appropriate places in the sewers, there would be storm relief outfalls delivering direct into the river, for the prevention of flood in times of exceptionally heavy rain.

If the combined schemes are not adopted, then the sewage pumps would be driven either by means of gas engines receiving their gas from the town mains, or (and this would probably be preferable) by gas engines working with "Dowson," or some other form of "producer gas." If, however, the electric lighting scheme is adopted, then, instead of gas engines, electric motors would drive the pumps, the cost of which would in either case be practically the same.

In the underground tank at the pumping station the sewage would be subjected to the action of, say, lime and sulphate of iron, or to the action of any other chemicals hereafter found to be more suitable. . . . Whether the power for working the sewage pumps is produced by gas engines or by electric motors, as has already been said, the first cost of the sewage scheme will be practically the same.

We have made a complete detailed estimate of this cost, and in our judgment the work should be easily carried out, complete in every respect, including the large sum asked by the owner for the sewage disposal site at Salts Lodge Farm, for the sum of £11,800 to £12,000 (say £12,000).

As regards the annual working cost of this sewage scheme, it will be better that we should assume that the pumps are to be driven by gas engines using "Producer" gas—(this gas being cheaper for such a purpose than is gas from the company's mains)—and not electrically, and we can, when considering the electric light scheme, give credit for this.

We estimate the annual working cost for the sewage scheme above suggested including every item, at the sum of £308, and allowing 5 per cent. on the cost of £12,000 for the repayment of capital, with interest on the same, and depreciation, *i.e.*, £600, we get the total annual cost for the scheme of £908, equal on a rateable value of £18,000, to, say, 12d. in the one pound sterling.

Combined Schemes for Sewage Disposal and Generation of Electrical Energy.

As we have just said, the carrying out of the sewage scheme alone will involve an original expenditure of £12,000, and will involve an annual expenditure equal to a rate of 12d. in the pound sterling, and we propose now to consider whether the addition of a scheme for the supply of electrical energy, if carried out on the lines of utilising the water-power at the Old Forge Mill, will enable you in the near future, when the whole product of the electric generating station is absorbed, to reduce the amount of the rate from the 12d.; or, to put it in another way, whether the receipts to be derived from the sale of electrical energy will not be so much that, when they are set against the annual expenditure, including every item, for the two combined schemes, they will reduce the £900 per annum (which is the cost of working the sewage scheme alone), and will thereby reduce the 12d. rate. Of course the whole question really turns upon the possibility or probability of there being such demand for the electrical energy as would justify you in the establishment of a station, under the peculiar circumstances of your case, which are, as your council will have gathered, much more favourable than usual in a town of the size of Monmouth. Upon a question such as this your council, with their intimate knowledge of the local requirements, are much better able to express a satisfactory opinion than we are, but we must remind you that we have had some considerable experience in the establishment of stations for the supply of electrical energy, and that we have had for years to consider the possibility of demand in towns of varying classes, and varying sizes, and having examined your town very closely, and having heard the result of private inquiries which have been made, and having ourselves made inquiries so far as it was possible, we are of opinion that, providing it could be done at a reasonable cost, your council would be perfectly justified in establishing a station capable of supplying at one time current for 1,000 lamps each of 16 candle-power installed, or stated in the general way in which electric light is now estimated, 2,000 lamps of 8 candle-power each installed. More especially would this be true if there were included in this amount of light, the light necessary for street lighting, replacing therefore the existing gas lamps by the superior electric light, and crediting the revenue of the electric light station with the present annual cost of the gas lamps. Under the above circumstances, we have examined the district with the object of ascertaining whether it was possible to in any way utilise some of the large amount of power running to waste in the rivers passing through your town. As has already been stated, practically the only suitable place which is available for obtaining water-power in or near the centre of the town, is the present disused Old Forge Mill on the Osbaston Road. We have already pointed out that this is close to both the suggested sites for the sewage disposal. We are informed, as the result of inquiries that have been made, that the owner of the property is prepard to lease the water-power here to the corporation, and also to lease sufficient land for the erection of an electric generating station. There is ample water-power for a reasonably large station, larger than it is probable you will require for a considerable number of years to come. To utilise some of this water-power we should propose to place at the Old Forge Mill three turbines, each being capable of giving, say, 35 indicated horse-power. These together, when working at their maximum, would generate electrical energy sufficient for, say, 1,700 8-candle-power lamps, or their equivalent, alight at one time, equal therefore to something like 2,500 8-candle-power lamps installed. We should suggest that there should be four alternating current dynamos (one being stand-by) each capable of absorbing the power developed by one turbine, there should also be three steam engines, each of similar power to the turbines, and the machinery should be so arranged that either the turbines or the steam engines, or both, should be capable of driving three alternating current dynamos working to a pressure of 2,500 volts. From this station we would lay (so far as is possible in the same trench as the pumping main for the sewage) an electric light and power main to the sewage pumping station, would there connect it to three alternating current motors, one for each set of pumps, to be used for pumping the sewage. In the sewage pumping station the high tension current, brought there by this electric main, would be transformed to low tension current of 100 volts pressure, and from the transformers to be placed in this station, and in, say, two other suitable places, the electrical energy would be carried by distributing mains to every part of the town where demand for current arises. From this distributing main the street lights would also be lit. The attendant in the sewage station would control the lighting by means of the transformers and apparatus placed in that station, and would also superintend the working of the sewage pumps and of the water pump hereafter referred to. Our estimate of the first cost of this work, allowing a small sum for the purchase of the land for the sewage and electricity transformer station, amounts to the sum of £5,600. We estimate the annual cost of working this installation, allowing a sum of £50 per annum as rental for the land and water-power at the Old Forge Mill, and allowing for every other possible item, including repayment of capital and interest on loan, at 5 per

cent. on the cost, all as in the sewage scheme, at the sum of £700 per annum. There is a further source of income which has been suggested, by which we think your council ought to benefit, and that is the present cost of pumping the water for the Cattle Market, and for flushing sewers, &c. This work could easily be done by the attendants at the sewage pumping station, which is close to the river, the water being taken from the river. The cost of the machinery for doing this, driven either electrically or by a gas engine, would be extremely small, and is included in our estimates. Experience shows that from each 8 candle-power lamp installed a revenue is derived equal to, say, 7s. per annum. In many cases this is exceeded, but the average receipt of 7s. per annum per 8 candle-power lamp may be assumed to be accurate for the purpose of this report.

At this rate, when 2,500 lamps, each of 8 candle-power, or their equivalent are installed, a gross revenue will be derived from the electrical generating station of £875 per annum. To this may be added the sum of £50 a-year to be saved from the pumping of water for use in the cattle market, and for use in flushing the sewers; and in considering the combined schemes there should also be added the cost of pumping the sewage, because this will form a revenue for the electric generating station, we estimate this cost as £150 per annum. The total annual income to be derived from the combined schemes therefore appears to be £1,075. The working cost of the schemes amount, as already stated, for the sewage scheme to £900 per annum, and for the electric lighting scheme to £700 per annum, deducting the £1,075 of income to be derived from the combined schemes, there is a balance left of £525 per annum, which will have to be found from the rates. This would involve a rate equal to, say, 7d. in the £1, or, in other words, your corporation would, by expending the larger sum of, say, £17,600 for the combined schemes, be able to carry out, and to carry on, the whole of the work with a rate of 7d. in the pound sterling, instead of a rate of 12d. in the pound sterling, which would be required if the sewage scheme alone, costing £12,000, is carried out. The above is based upon an estimated output from the electric generating station, equal to 2,500 lamps of 8 candle-power each installed. When this output is exceeded the income will be correspondingly increased, while there will be but less proportionate increase in the expenditure, that is to say, the suggested rate of 7d. in the one pound sterling will be still further reduced. To sum up the whole matter, in our judgment your council should at once proceed to carry out a sewage scheme on the lines we have indicated, combining with it the scheme for the generation of electrical energy, as there is no doubt that the annual rate for carrying out and working the sewage scheme alone would exceed the annual rate required for the suggested combined schemes, when all items are taken into account.

(Signed) Bramwell & Harris.

BUSINESS NOTICES, &c.

Universal Electrical Directory (J. A. Berly's).—Messrs. H. Alabaster, Gatehouse & Co. have now in course of preparation the 1895 edition of this directory, which embraces all connected with the electrical trades throughout the Universe. It is indispensable to all having business transactions in the electrical world.

Aberdeen.—Through the National Telephone Company, the inhabitants of Skene and Echt can now communicate with Aberdeen by telephone.

Ashton.—A local paper suggests that "if the corporation could, by agreement with the Tramways Company, purchase the tramways passing through the borough, it might be as well to consider also the advisability of working the cars by electricity. The plant which would be required for electric lighting, would, if used for illuminating purposes alone, only be required to work during a portion of each day—that portion which was dark, and, therefore, during the daytime it would be at liberty for supplying tramcars with the motor power for running them. In winter time the two would overlap for a few hours, but this difficulty is by no means an insuperable one. At any rate, when the sub-committee begin their investigations, nothing can be lost by looking at the questions from every point of view."

Ayr.—The Secretary for Scotland has sanctioned the borrowing of £15,000 for electric lighting.

Bath.—Since January last the City of Bath Electric Lighting Company have been experimenting with liquid fuel. The engineer (Mr. Metzger) is not only trying various liquids, but also various makes of injectors. There was at first a great deal of trouble with the smoke, but we understand that this and many other difficulties have been overcome, and shortly a long series of tests is to be started. The results are said to be very encouraging.

Bedford—Tenders are shortly to be advertised for for wiring the Corn Exchange, the Town Hall and the Town Hall offices for the Town Council.

Belfast.—The following scale of rebates on electric current accounts has been adopted by the City Council on the recommendation of the Electricity Committee:—On quarterly accounts of £2 10s. and up to £5, 2½ per cent.; £5 and up to £7 10s., 5 per cent.; £7 10s. and up to £10, 7½ per cent.; £10 and up to £20, 10 per cent.; £20 and up to £40, 12½ per cent.; £40 and up to £90, 15 per cent.; £70 and upwards, 17½ per cent. The works in connection with the central station and the laying of the mains are progressing satisfactorily, and some of the engines have undergone preliminary tests.

Birkenhead.—The Council have approved, subject to certain alterations, Mr. J. N. Shoolbred's plan in connection with the proposed central station, and the Local Government Board are to be applied to for sanction to the borrowing of £20,000 to carry out the scheme.

Bolton.—Some time next month the central station in Spa Road is to be opened with the usual ceremony.

Blackpool.—The terms of Messrs. de Ferranti, Limited, for loan of a 55-light set of rectifying apparatus, with option of purchase, have been accepted by the Town Council.

Some complaints have been made of the slow speed at which the electric trams run, and in response it has been stated that it was not the fault of the cars, but it would be hardly safe to the general public for them to go at a greater speed.

Bradford.—A statement was read at a meeting of the City Council this week, stating that the electricity accounts for the past half-year, showed that £4,963 18s. 3d. had been received for the sale of the current, and the total receipts had been £5,418 7s. 10d., against £4,547 8s. 3d. during the corresponding half of last year. The gross profit was £2,189 0s. 4½d., against £2,293 15s. The gas works have made a greater profit than usual by several thousand pounds.

The People's Palace and Star Music Hall is being extensively altered, and is lighted by electricity throughout.

Brighton.—The Theatre Royal has lately been reconstructed, and one of the many improvements is the addition of the electric light on the three-wire system, current being obtained from the Corporation's mains. There are, in all, about 600 16-C.P. incandescent lamps, which are distributed about the entrance halls, lobbies, staircases, gallery, and the stalls; about 400 of the lamps are on the stage. Messrs. F. Geere Howard and E. S. Dashwood, of 10, Berners Street, W., carried out the electric lighting work.

Cardiff.—We understand that all the machinery is in position at the central station, and arrangements are nearly completed for the introduction of the light. This will probably take place within the course of a few days.

Messrs. Knapman, Hodder & Co., Cardiff, have secured the order for placing in a complete electric lighting installation, with accumulators, in the extensive Draycott Roller Flour Mills, Cam, Gloucestershire, together with private residence, workmen's cottages, and stables.

Cheltenham.—Some correspondence has passed between the Town Council Electric Lighting Committee and the Brush Electrical Engineering Company, who appear to have misread the contract for the transformers. The electric lighting station is proceeding satisfactorily, and the contractors (Messrs. Malvern & Sons) have become entitled to a first advance of £400.

Derry.—Mr. Christie has presented his report regarding the recent failures of the electric light here. He states that between August 22nd and September 4th, seven failures took place, placing about one-fourth of the portion of the city lighted by electricity in darkness for a night on each occasion. Six of the failures were due to faults in the cable at different parts of the circuits. In the seventh case the failure, which extinguished 22 lamps, was caused by a faulty contact in one of the lamps. The failures, Mr. Christie added, were not at all attributable to any action of his or his staff. A letter was read from Messrs. Siemens Brothers, declining to admit that the repeated failures in the cable were due to defective manufacture or to careless handling on the part of their men. As, however, they were greatly interested in the success of the installation, they would consider the question of defraying the expense to which the Corporation had been put in re-opening and closing the streets to reach the defective parts of the cables. A question was asked regarding any suggestions for preventing these failures in the future, but Councillor Hastings said such questions could not be answered. Messrs. Siemens Brothers were responsible for the working until May 29th, 1895, when their period of maintenance would terminate. It transpired that Mr. Blake, the electrical engineer, under whom the installation was introduced, had gone to London to consult Dr. John Hopkinson, the consulting electrical engineer, who had already passed the specifications. The consultation took place with reference to the failures in the cable. Dr. Hopkinson's opinion had not yet arrived.

Devonport.—The County of London and Brush Provincial Electric Lighting Company, Limited, and the Great Western Electric Light and Power Company, Limited, have notified the Town Council of their intention to apply for an electric lighting provisional order.

Dover.—The Council have received notice of intention of the Company to lay electric light mains in Stroud Street and Wood Street.

The *Dover Standard* illustrates the new station—south and west elevations—and states that the work of erection is progressing.

Dundee.—Messrs. William Ramsay & Co., of Glasgow, have secured the contract from ex-Bailie Taylor for the illumination by electricity of his business premises in Yeaman's Shore and his steamer *Alice Taylor*. The offices, stores, stables, and workshops are to be lighted, and four arc lamps, each of 2,000 candle-power, are to be provided for the yards.

Eastbourne.—The Central Ward Sub-committee have had referred to them by the Town Council the question of erecting an electric light column at the top of Victoria Place, and of the provision of two additional lamps, one at each end of the Grand Parade Shelters on the Central Parade.

Eccles.—The Electric Lighting Committee have visited Whitehaven to inspect the electric lighting arrangements there, but are not yet in a position to make any recommendations to the Town Council.

Fareham.—Major Cardew, on behalf of the Board of Trade, last week held an enquiry regarding the transfer of the electric light undertaking from the possession of the electric light company to that of the Local Board. The opposition to the purchase was very strong.

Gateshead.—The surveyor has made a report as to the advisability of introducing electric lighting into the borough.

Glasgow.—The report of the Lighting Committee on gas and electric lighting has been issued. The report is for the year from June 1st, 1893, to May 31st, 1894. The gross revenue amounts to £18,015 19s. 2d., and the gross expenditure to £9,591 19s. 5d., to which is added depreciation written off capital, £4,393 0s. 11d.—together, £13,985 0s. 4d. The balance carried to profit and loss account is £4,030 18s. 10d. Deducting from this the balance of £4,030 18s. 10d., there remains a deficiency on the year's operations of £607 7s. 9d., which has been transferred to the debit of the gas account. This result of the first full year's working of the three-wire low-tension system compares favourably with the result of last year's operations, when the deficiency was £1,773 12s. 1d. The revenue has increased from £7,784 5s. 4d. to £18,015 19s. 2d. The committee anticipate that this improvement will not only be maintained, but that the use of electricity will be further developed during the current year. On July 25th the committee recommended that the price of current be reduced from 7d. to 6d. per Board of Trade unit as from June 1st. The number of consumers on May 31st last was 378, being an increase of 270 over the number at same date last year. The quantity of electricity sold during the past year to private consumers, irrespective of public lighting, was 543,178 Board of Trade units, being an increase over the preceding 15 months of 107·14 per cent. Some other accounts which have been published include the following expenses connected with the municipal buildings:—electric lighting, £998; gas, £228; rent of telephones, £173.

Inverness.—Two companies intend applying for provisional orders. The Town Council has refused its consent to the applications.

Larne.—Complaints being made regarding the inferior quality of the electric lighting lately, the matter has been referred to the Lighting Committee.

Leicester.—The electric lighting of the premises of the Leicester Co-Operative Society, it is stated, will cost about £1,500, instead of £1,000, as estimated. The annual cost of lighting is estimated at about £356, which was equal to 4½d. per unit, whereas the Corporation's estimate was 6d. per unit, or £450 per annum.

The City Corporation Expenses.—The *City Press* has lately published some very interesting particulars showing in detail the expenses incurred in the City during last year, in the administration of justice within one square mile. Among the various expenses we observe the following amounts expended upon electric lighting and telephone work:

Justice Room, Mansion House:—			
Installation of electric light	£12	3	0
Justice Room, Guildhall:—			
Rent of telephone	9	10	0
Expenses of the Civil Government of the City (Mansion House and Mayoralty Expenses):—			
National Telephone Company, for one year's rental of lines and instruments	59	16	6
Messrs. Edison & Swan, and others, for lamps and fittings for electric light	173	1	0
City of London Electric Lighting Company for current supplied for one year	881	9	9
Mr. Surveyor, wages *re* attendance to electric light	252	7	6
Planet Electrical Engineering Company, for experimentally lighting the Egyptian Hall	133	16	9
Lightning conductors to flagstaff	23	10	0
Guildhall, the Courts and other Buildings:—			
Gas	1,148	9	3
Messrs. Lund Brothers, balance of contract for fitting the Guildhall, the Library, and the Council Chamber with installations of electric lighting	502	1	10
Ditto, for fitting electric light in committee rooms	330	16	3
Ditto, for ditto to the Guildhall Museum ...	360	0	0
Mr. W. H. Preece, for professional charges *re* ditto	65	2	1
City of London Electric Lighting Company, for current supplied for one year	259	10	4
Lamps and fuses	32	5	3
Rent of telephone wire to fire station ...	10	0	0
Electric bells and repairs	43	5	10
Testing gas meters	14	10	0
Repairs to boilers	91	0	0
Repairs to lightning conductors	37	11	1
Mr. A. Waller, further on account of contract for regilding gasoliers in Guildhall ...	60	0	0

Llandudno.—A very successful installation of arc lights has recently been completed by Mr. William Kingsland, in the grounds connected with Riviere's Concert Hall. The lamps are of the Brockie-Pell type, and are driven from a gas engine and shunt dynamo. They are said to add greatly to the attractions of the gardens.

Lincoln.—The Town Council have refused their consent to the application of the County of London and Brush Provincial Electric Lighting Company for sanction to apply for a provisional order. The Council contemplate carrying out the work of electric lighting themselves.

Luton.—A member of the Council last week gave notice of his intention to move shortly that a report be prepared by the Lighting Committee as to the advisability of going in for electric lighting, and the probable cost of such a scheme.

Manchester.—Messrs. Drake & Gorham, through their Manchester branch, have been pushing ahead in that city and the electric lighting work in connection with Messrs. Mudie's Library has been placed in their hands.

Middlesborough.—The result of the sub-committee's visit inspecting the electric lighting arrangements of a number of other towns is that they recommend the Corporation to proceed at once with the laying down of an electric lighting installation at a cost not exceeding £25,000. The committee were exceptionally pleased with the Huddersfield, Blackpool, and Leeds installations.

Monmouth.—By seven votes to six, the Town Council have appointed Mr. Lailey, C.E., of Westminster, to prepare plans and specifications for the combined scheme for drainage and electric light in the borough. He will work along with Messrs. Bramwell and Harris.

Motherwell.—The Scottish House-to-House Electric Lighting Company intend applying for a provisional order, but the Commissioners will not consent to the application as they are at present in consultation with Mr. Mavor, of Glasgow, with a view to formulating a scheme for lighting the town themselves.

Nelson.—The Gas Committee of the Council have, on the petition of the local Tradesmen's Association, resolved to reduce the electric light charges as follows: Reduction in the rents of 3s. to 2s. per quarter, and a discount of 5 per cent. for cash in 14 days on accounts for electric light supply.

Norwich.—The new Catholic church is lighted throughout electrically, as follows:—In the nave, 80 lamps of 25 C.P. each, fixed on double brackets, 2 lights on each bracket at the bottom of the triforium. In the aisles, 40 lamps of 25 C.P., 20 lights in each aisle, fixed on single brackets, one light to each, on the capitals of the pillars. In the main entrance, 4 lamps of 25 C.P., fixed on single brackets, one light to each, on capitals of columns. All the brackets and lamp-holders are of aluminium. The main switchboard from which all the lights are controlled is fixed at the east end. The Presbytery is fitted throughout with the electric light, in all 46 lamps of 16 C.P. Messrs. Lawrence, Scott & Co., carried out the work.

Oldham.—The large new picture gallery belonging to the Corporation is being fitted throughout with Messrs. Verity's registered picture reflectors.

Preston.—The Electric Lighting Committee reported that they had deemed it advisable to authorise Dr. John Hopkinson to advise them on the question of lighting by electricity the Town Hall and Public Hall—his terms therefor being 5 per cent. on the cost of lighting with a minimum of 50 guineas and travelling expenses. This course has been adopted by the Town Council by 23 to 7 votes.

Portsmouth.—Since the electric light was turned on the disturbances on the telephone lines is said to render communication over them almost impossible.

There was an explosion of gas under the pavement in High Street last week, and the lid of one of the electric lighting main boxes was forced up. Alderman Ellis examined the spot afterwards, and it is asserted the electric lighting apparatus is in no way responsible for the accident.

Reading.—Sixteen out of the twenty shops forming the Arcade in Friar Street are lighted by electricity, current being supplied by the Reading Electric Supply Company, Messrs. T. C. Williams & Sons, and Mr. J. W. Dew, providing the fittings. The central part of the Arcade is lighted by six electroliers. The County Court offices, which form a portion of the new block, and the other buildings, are also to be lighted by electricity.

Redditch.—The Local Board the other day decided to postpone the erection of additional lamps until the committee have sent in their report regarding the lighting of the town by electricity.

Rugby.—A deputation (including Mr. Cotterell, the National Telephone Company's district manager) waited upon the Local Board the other day, when the question of overhead telephone wires was discussed.

Salford.—The Gas Committee are in want of a properly qualified mechanical and electrical engineer to act as clerk of works and superintend the erection of the engines, dynamos, &c., at their electric light station, and the laying of mains. Should the person appointed prove suitable, he will, on completion of the works, be retained as superintendent. Applications to be addressed to the chairman of the Electric Light Committee, Town Hall, Salford, by 5 p.m. on 15th inst.

St. George's, Bristol.—A committee of the Local Board has been appointed to consider the advisability of undertaking the supply of electricity within the district. The mover of the resolution

said he would not suggest that they should go in for any such ambitious scheme as they saw in Bristol, and he did not want them to spend £25,000 on the building or anything in proportion to it. He would suggest machinery £4,000, site £1,000, building £1,000, and say installation £4,000. That would be a total of £10,000. They could borrow the money repayable in 30 years; that would be about £300 a year, while the cost of maintenance would be say £1,000 a year. So that their expenditure altogether would not reach £2,000 per annum, or the sum they were at present paying for gas. They would be able for the same sum, or less, to provide a larger number of lamps.

Sheffield.—The chairman of the Sheffield United Gas Light Company said, the other day, that "the Incandescent Gas Light Company had, in his opinion, put a weapon in the hands of the gas companies which would enable them to compete in a satisfactory manner with the electric light, for with the incandescent gas burner they could supply as good a light, and a much cheaper one, than that provided by electricity."

Shoreditch.—A noisy meeting of the Vestry last week discussed the question of appointing Messrs. Kincaid Waller & Manville as consulting engineers to carry out the electric lighting and dust destructor scheme at a commission of 3 per cent. No decision was arrived at, as the meeting appears to have been one continuous uproar, and a division on the matter being ultimately demanded.

Southport.—A member of the Town Council the other day suggested the lighting of the Promenade by electricity, but at present there is no intention of such a step being taken.

Stockton.—The Board of Trade has promised to defer considering the question of revoking the Town Council's provisional order for two years, on the faith of their undertaking that within two years the electric light will be installed by them.

Streatham.—The proprietor of the Greyhound, Mr. Janes, has lately introduced the electric light. Mr. George Stegman, of Clapham Junction, is responsible for the complete installation. The house is lit by 80 lights of 16 candle-power each. The power is obtained from a gas engine of 7 horse-power, which drives compound wound dynamos. There is power enough for 150 lights.

Taunton.—The Town Council have resolved to apply to the Local Government Board for power to borrow £5,000 for extending the electric lighting undertaking.

Tunbridge Wells.—It is expected that the new electricity works will be completed in February next.

Uruguay.—A central electric lighting station has just been completed and put in operation in the town of Salto, Uruguay.

Warminster.—The electric light is to be extended from the fountain at the bottom of Station Road to the Obelisk, by the addition of six additional lamps.

Wells.—At a recent meeting of the Council a letter was read from Messrs. Davies & Roach, of Wells, on behalf of Mr. A. D. D. Browne, electrical engineer, of Shepton Mallet, enclosing an application for a license to supply electricity to the city for public and private purposes. The matter has been referred to the Lighting Committee.

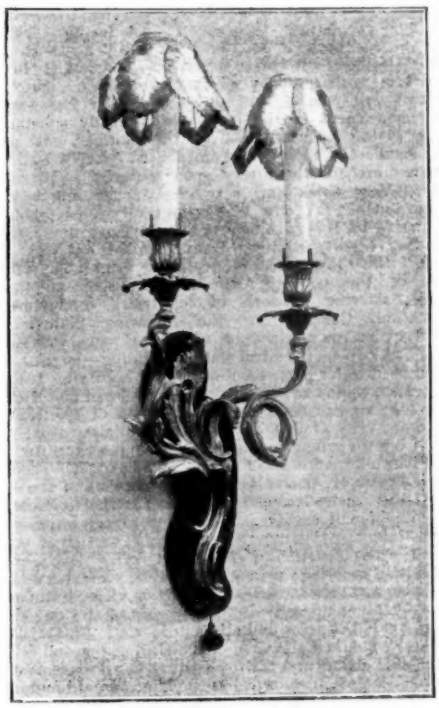
Yeadon.—The tenders sent in for the proposed electric lighting installation are all higher than was expected. An electrical expert is to be called in to advise regarding them.

Australia.—The Legislative Assembly on July 25th had before them at Melbourne for second reading the Electric Lighting Bill. In the course of the debate, Mr. Cuthbert said he thought the price of electricity should be left to the contracting parties, and not placed in the hands of the Governor in Council. He directed attention to the provision in clause 45 that fees were to be paid to the Minister, which, he considered, should be struck out. Mr. Sachse held that there should be some restriction of the tension of current in the interests of public safety, and that the proper system was to lay the cables underground, except in country towns, where the overhead system would be quite safe enough and the cost of the underground wires would be prohibitive. This was a very technical measure, and should be referred to an expert committee.

Berlin.—In a recent issue we referred to the increasing consumption of electricity and the decreasing demand for gas in Berlin. Concerning the use of the electric light it appears that at the close of 1893 8,800 arc lamps, 172,067 incandescent lamps, and 322 electric motors were supplied with current, being an increase over the previous year of 780 arc and 31,791 glow lamps and 130 motors.

German Trade Mark Law.—It may interest our readers to know that a new German trade mark law comes into operation on October 1st next. According to the present law, British marks are registered at Leipzig, but under the new law all previously recorded marks must be entered on the Imperial Register at Berlin. The sooner this is done the better, as the first applicant secures priority, and marks previously registered at Leipzig, unless re-registered, will be disregarded by the Berlin officials when dealing with new applications. Owners of trade marks entered on the Imperial Register will be officially informed of any applications for similar marks for the same goods. Infringers of registered marks will be liable to fine and imprisonment, and also to pay an indemnity to the registered proprietor. Any further information respecting the above can be supplied by Mr. Reginald W. Barker, F.I.Inst.F.S.P.A., at the British Trade Protection Office, Monument Chambers, E.C.

Waltham's Combination Bracket Fitting (an engraving of which was shown in last week's issue) can also be applied to brackets of similar construction and design. The accompanying illustration shows one of the firm's specialities; it is highly chased,



and fitted with their new tassel switch and sliding connections. This combination, which has been protected against infringement, is mounted on porcelain and other insulating materials. It is of a novel and useful character, being let into the bracket block, and entirely concealed from view. The tassels and plush mounts are made in any colour to suit the existing decorations of the room. These brackets can be seen in the showroom of Messrs. The Waltham Electrical Engineering Company, Chapel Place Works, Westminster (back of St. James's Park Station), who make a speciality of this class of work, and have special facilities for carrying out work to architects' own design, adapting every kind of fitting for the electric light. They also manufacture switchboards, &c., to design.

"Daily Chronicle" New Offices.—The new offices of the *Daily Chronicle*, which have been erected in Salisbury Square, E.C., for the accommodation of the proprietors and directors, have been fitted with a telephone installation by the Private Wire and Telephone Installation Company, of 110, Cannon Street. Instruments have been fitted in the various rooms, and the wiring done on the intercommunication system, by which all the various parts are enabled to have instant and direct communication with each other, while dispensing with a central switchboard, thereby saving much time and labour. All the instruments, which are "Magnetos," and are fitted with Hunnings' transmitters, have been specially made in oak, and each point is provided with a small keyboard, in which are fixed small sockets, which are labelled for the various parts, communication with which is obtained by the insertion of a plug. In all, eight rooms are fitted up, five with desk sets and three with wall sets; in the board room the instrument is portable, and can be used by any one at the long table which covers the length of the room. Electric bells have also been fitted throughout the building by the same company, dry batteries being employed throughout.

Central Station Instruments.—Messrs. Swinburne and Co., Limited, have brought out a new series of central station instruments. For the purpose of bringing the instruments before the public at once, the firm has decided to book all orders received before October 1st at much cheaper prices than will eventually be charged. The continuous current set consists of one Swinburne standard voltmeter (N type) to read to 150 volts, one Swinburne standard ammeter to read to 50 ampères, one voltmeter switch, the whole mounted on a mahogany (polished) switchboard. The alternating current set consists of one Swinburne standard voltmeter (U type) to read to 100 volts, one Swinburne standard ammeter to read to 20 ampères, one Swinburne standard wattmeter to read to 2,000 watts, one voltmeter switch, the whole mounted on a mahogany (polished) switchboard.

Bankruptcy.—A receiving order has been made at the London Bankruptcy Court against the estate of William David Gooch, electrical engineer, late of 3, Victoria Mansions, Westminster. The petition was lodged on behalf of a creditor, and the debtor states that he has no assets whatever. He has relinquished the office at Victoria Mansions, and resides at Willis Road, Kentish Town, the household furniture being the separate property of his wife. The amount of the liabilities did not transpire.

Central Stations at Cologne and Amsterdam.—An immense volume, 22 inches by 16 inches, has been brought out by the International Electric Company. The book, which is titled, "The Electric Central Stations at Cologne and Amsterdam," is by Carl Coerper, the managing director of the Helios Company, Cologne-Ehrenfeld, and has been translated from the German by an electrical engineer named Clarence P. Fieldmann. The translator and author each open the book with a short preface. The two stations are first described in detail in letter-press, and this is followed by 33 exquisite plates, each of them covering two full pages. Some of the smaller ones appearing at the commencement of the book are tastefully coloured. The phototypes, giving various views of the stations, are excellent work; the smallest of these views are about 17 inches by 13 inches, and they are each of them very good pictures, and are beautifully clear. Very thick and very good paper has been used, which helps the effect of the illustrations very considerably. This splendid album—for it is nothing less, and we have never seen anything to beat it—is strongly bound, and is a very suitable volume for the libraries of electrical men. The following is a list of the contents and plates:—Plan of the town of Cologne, showing network of electrical conductors. The central station, Cologne, has the following plates: plan of engine and boiler room, elevation of engine room and section of engine and boiler room. Central station building—interior view of boiler room, feed water pumps and device for purifying feed water; plan of 600 H.P. engine and alternator; elevation of 600 H.P. engine and alternator; view of engine room; elevation of 125 H.P. engine and alternator; view of 600 H.P. engine and alternator; view of platform with lever arrangements; table of connections for running in parallel four alternators and four compound exciters. Then follows a plan of the town of Amsterdam, showing network of the electrical conductors; the Amsterdam central station has the following plates to describe it: plan of engine and boiler room; elevation of boiler room; elevation of engine room; elevation and section of boiler and engine room; front elevation of engine and boiler room; east view of central station building; west view of ditto; elevation and section of boiler; plan and section of boiler; interior view of boiler room; plan of 600-H.P. engine and alternator; view of the engine room; elevation of 600 H.P. engine and alternator; view of 600-H.P. engine and alternator; plan and elevation of 125-H.P. engine and alternator; view of 125-H.P. engine and platform, with lever arrangements; view of transformer house; plan of 600-H.P. engine and alternator; elevation of 600-H.P. engine and alternator. Copies of the book are on sale by Messrs. H Alabaster, Gatehouse & Co., 22, Paternoster Row, at £3 3s. each.

Electricity in Mining.—A new colliery which is being opened out on the Park Hall Estate, near Eckington, is to be worked entirely by the transmission of electrical power. It has been decided to put down high-pressure boilers and high-speed engines and dynamos. The under-cutting of the coal will be entirely done by "Jeffrey" electric coal-cutting machinery of the latest type. The ventilating fan is to be driven by an electric motor. All the surface and underground workings will be lighted electrically. Messrs. John Davis & Son, of Derby, have been entrusted with the whole of the electric work.

Roger Dawson, Limited.—This firm is engaged putting over 3,000 lights into Wellington Court, Knightsbridge; also in doing work for the following, among others:—Earl Rosebery; Princess Soltykoff, Slough; Earl Cowper, K.G., 4, St. James's Square; Countess of Shaftesbury, 5, Belgrave Square; Sir H. D. Gooch, Windsor; Lady Vivian, 6, Cadogan Square, S.W.; Lady Emily Peel, 12, Stratton Street, W.; the Hon. Miss Portman, Bournemouth. Also the firm is supplying the electric light fittings for the Government offices, Downing Street; complete fittings for Marshall, Sons and Co., Limited, Gainsborough; Sir G. Stuart Knill, Rochester Buildings.

Electric Cooking.—There has just been opened by Mr. Jesse Percival, at 38A, Queen Victoria Street, E.C., a restaurant where the cooking is done entirely by means of electricity. Mr. Jesse Percival has had experience as a caterer in Manchester, Leamington, and Scarborough. The dining and smoking room is lit by electricity, as is also the kitchen, where are two large ovens, one for roasting and one to serve as a hot closet. The current and cooking apparatus were supplied by the City of London Electric Lighting Company.

Price Lists.—Messrs. Louis Dernier & Co., of Newman Street, Oxford Street, have sent us one of their lists of new designs in silk lamps and electric shades; some of the designs are very neat and tasteful; prices are stated.

Electric Blasting.—The *Dean Forest Mercury*, in a lengthy report of the annual gathering of the National Association of Colliery Managers, records some extensive blasting operations which were carried out by the Electric Blasting Company, Limited, in the presence of a number of the Association members and visitors.

Telephonic Communication in Italy.—It is stated that trunk telephone lines are about to be established between Rome, Florence and Venice; Rome and Naples; Rome, Genoa and Turin: Rome, Florence and Milan; Turin and Milan; Turin and Genoa; Genoa and Milan; and between Milan and Venice.

Auction Sale.—A rather important sale of electric material is announced; we refer to the estate of Woodhouse and Rawson United (Limited). Full particulars can be obtained of F. D. Leslie (Robinson & Leslie), receiver and manager, 74, Coleman Street, E.C.

Drake & Gorham.—This firm has been entrusted with the electric lighting of the premises of the Royal Geographical Society and they are arranging for 120 lights of various candle-powers, the current being obtained from the supply mains.

Change of Address.—Messrs. J. C. Fuller & Son, electric telegraph engineers, formerly of 547, Old Ford Road, Bow, E., have removed to Woodland Works, Wick Lane, Old Ford Road, E.

Books Received.—"Practical Designing of Structural Ironwork." By Henry Adams, M.Inst.C.E., &c. First series, revised and enlarged. Published by E. & F. N. Spon.

Football.—A football match was played at Rochdale on Tuesday, last week, by the aid of electric light before 3,000 spectators.

CONTRACTS OPEN AND CLOSED.

OPEN.

Bristol.—September 18th. Estimates are required for the construction of transformer chambers in certain streets in Clifton, for the Electrical Committee. Specification, &c., may be inspected on application to Mr. H. Faraday Proctor, M.I.E.E., city electrical engineer, Temple Back.

Cheltenham.—September 18th. Tenders required for the construction and erection of a 7-ton hand-power overhead travelling crane at their electric lighting station in the borough, for the Town Council. Specification, &c., on application to the borough surveyor, Municipal Offices.

France.—September 20th. The General Direction of the French Posts and Telegraphs, 103, Rue de Grenelle, Paris, is inviting tenders until the 20th inst. for the supply of 10,000 galvanised iron cross bars for telegraph poles.

Glasgow.—September 18th. Tenders are wanted for the construction of about half-a-mile of double line of tramway, for the Tramways Committee. Specifications, &c., may be obtained on application to Mr. John Young, general manager, 88, Renfield Street, Glasgow.

Kingstown (Ireland).—September 17th. Tenders are wanted for the supply, in such quantities as may be required from time to time during 12 months, of the following, among other stores, for the Commissioners, according to specification: lamp-posts, lanterns, governors, lever cocks, lighting poles, &c.; Dublin Corporation, Vartry supply pipe, stopcocks, ferrules, hydrant balls, lead, block tin, &c.

Reading.—Tenders are wanted for the erection of buildings above the concrete foundations for new central station on land near River Thames, Vastern Road, Reading, for the Reading Electric Supply Company, Limited. Particulars from Mr. Fred. W. Albury, architect, 154, Friar Street, Reading.

Stockport.—September 19th. The Town Council want tenders for combined pumps and engines, four steel boilers, and an overhead travelling crane. Full particulars from Mr. A. M. Fowler, 1, St. Peter's Square, Manchester.

CLOSED.

Bolton.—The tender of the National Boiler Insurance Company has been accepted for the insurance of the steam boilers at the central station.

Bradford.—The following tenders have been accepted for the supply of goods required in the several departments during one year ending August 31st, 1895, for the Gas and Electricity Supply Committee:—Wet and dry gas meters, G. Glover, J. Milne and Son, J. and J. Braddock, W. Parkinson; pipes and castings, Clapham Brothers, E. and W. H. Haley, J. and W. Knowles; gas and steam wrought-iron tubing, Taylor & Parsons; best merchant iron and wrought-iron grate bars, Perkins, Son & Barrett; steel (tool steel bars and sheets), W. Cooke, Inman & Co.; bolts and nuts, Taylor & Parsons; best engine oil, Palmer & Co., Limited; common engine oil and cylinder oil, J. E. Williamson; boiled linseed oil and tallow, D. Salmon, Son & Nephew.

Bury.—At the last meeting of the Council there was a lengthy discussion on the letting of the electric lighting contract. The tender of Messrs. Storrs & Sons, of Stalybridge, has been accepted. Messrs. Storrs's tender was about £160 less than that of the local firm.

St. Pancras.—The following is a list of the tenders sent in for the supply and laying of armoured cable mains for electric lighting, for the St. Pancras Vestry:—

Fowler-Waring Cables Company, Limited (accepted)	£1,750	14	6
Siemens Bros. & Co., Limited	1,812	11	1½
Callender's Bitumen Telegraph Company, Limited	1,872	11	0
British Insulated Wire Company, Limited ...	2,073	6	3
India-Rubber, Gutta-Percha Company, Limited	2,084	1	4
W. T. Henley's Telegraph Works Company, Limited	2,084	6	6
W. T. Glover & Co.	2,339	2	2
Reid Bros.	2,428	17	2

Dundee.—We understand that several of the tenders sent in for the steam engine and dynamo for the Dundee Gas Commission varied somewhat considerably from the specification. The accepted tender was that of Messrs. Siemens Bros. & Co., Limited, for a Willans II. engine and Siemens dynamo, the price quoted being £1,466.

West Bridgford (Notts.)—The tender of Messrs. Tinker, Shenton & Co., Hyde, Manchester, has been accepted for supplying and fixing a new boiler at the pumping station for the Local Board. Fifteen tenders were sent in.

Worcester.—The following were the three tenders sent in for wiring the electricity generating station at Powick for electric lighting for the Watch Committee of Worcester Town Council:—

Paterson & Cooper, Westminster (accepted) ...	£206 0 0
The New British Electric Installation Contractors, Limited, Worcester	254 4 0
Brush Electrical Engineering Company, London	257 13 6

NOTES.

Grant Allen on India-Rubber. — In the September number of *Longman's Magazine*, Mr. Grant Allen discourses on India-rubber under an article entitled, "The Cinderella of Civilisation." Grant Allen proceeds to prove the indispensability of India-rubber, and that, in fact, a rubber-less world would be a hideous reality. Without India-rubber or gutta-percha, telegraphy, if not electric lighting, would be next to impossible—at any rate, with other countries.

Overland Telegraph between India and China.—The *Daily Chronicle* of September 7th says, amongst other matter:—"The last issued number of the Treaty Series of the present year, just issued from the Foreign Office, contains the terms of the convention between China and Great Britain in reference to the delimitation of the Burmese frontier, and includes an undertaking that the telegraphic systems of the two countries shall be joined up together." The present termini at Tingyueh and Mogoung, in China and Burmah respectively, are, roughly, about 200 miles apart, and the filling up of this gap in communication between Calcutta and Pekin should not be a very difficult matter. When this work is complete it will be possible to telegraph from London to Pekin without employing the land-lines through Russia and Siberia, or the cables of the Eastern and Eastern Extension Telegraph Companies, which lie exposed to interruption in the event of international complications. The completion of this line is, therefore, much to be desired, and the inclusion of this work in the treaty with China evinces more forethought than is generally shown in our foreign diplomatic action. With reference to the same subject the *Pioneer* says:—For some time negotiations have been in progress with China to secure the linking up of the telegraph lines which have their termini in the Bhamo district and Yünnan respectively. The Indian system has approached within a few miles of the extreme western frontier of China, while the Chinese wires have been carried well into Yün-nan. There is, probably, a gap of less than 200 miles between the stations, and this could be bridged over in a few months if the Peking Government and the London Foreign Office came to an agreement on the point. Then there would be overland communication between India and China, and the cost of telegraph messages between the two countries would be considerably reduced. Both from a commercial and a political point of view it is most desirable that this through line should be completed; but there is likely to be further delay now that China has her hands full with the war in the Corea.

"An Agreeable Electrical Relish."—In a recent issue of a certain weekly paper which aims at the popular exposition of scientific matters, is often amusing when it evidently means to be taken seriously, and which we will call "S. S."—initial letters which do not stand for "Scissors and Stickphast"—the reason why a pewter pot is to be preferred to a glass when drinking beer is gravely discussed. It is claimed that a more brisk gustatory sensation is experienced when drinking beer out of a pewter than when it is taken from a tumbler, and the cause is ascribed to galvanic action. "In this instance, we read, "there is a galvanic circle (*sic*) formed by the combination of one metal and two dissimilar fluids. In the act of drinking, one side of the pewter pot is exposed to the action of the saliva which moistens the lip, while the other metallic side is in contact with the malt liquor. The galvanic circuit being thus completed, an agreeable electrical relish is communicated to the beverage as it comes in contact with the tongue." It was Sulzer, nearly 150 years ago, who remarked that "if you join two pieces of lead and silver, and then lay them upon the tongue, you will notice a certain taste resembling that of green vitriol, while each piece apart produces no such sensation." What a foolish person Sulzer was to demonstrate this fact in galvanism by such a nauseous experiment, when a pewter pot and a pint of bitter would have provided the *agreeable electrical relish* described by our contemporary. We do not propose to discuss this matter seriously, so we will dismiss it with the time-honoured observation that there are evidently more things in heaven and earth than are dreamed of in our philosophy.

A New Form of Mercury Air Pump.—Electricians interested in the production of vacua, whether in commercial operations or in philosophical research, should consult a recent number of the *Berichte der Deutschen Chemischen Gesellschaft*, xxvii., pp. 1,386—1,394. Here is described in great detail, and with good illustrations, a new form of mercury air pump by G. W. A. Kahlbaum, which, so far as we can judge from the text, appears likely to be of great service. Mercury is allowed to pass down a fall-tube into a reservoir, *à la* Sprengel, from which it is again elevated by means of a water pump to the supply reservoir, which is thus kept constantly full. To avoid the introduction of water-vapour phosphoric anhydride, a very hygroscopic substance, is placed in a receptacle between the water pump and the mercury. A pressure gauge is a useful feature in the apparatus.

Who is Prof. Wanklyn?—The week before last we published a letter from a very eminent chemist named Prof. Wanklyn, who, like ourselves, discredited the asserted discovery of a "new gas" by Lord Rayleigh and Dr. Ramsay. A hypercritical contemporary betrays ignorance in last week's issue by making the admission that the captious individual penning its so-called "Review of Reviews" is "tempted to ask who is *Mr.* J. Alfred Wanklyn?" We would refer him to the "Science Notes" column of the *Daily Chronicle* for last Tuesday, from which he will discover that the professor is not altogether unknown. Prof. Wanklyn is there described as "another distinguished chemist of even longer experience" than Prof. Dewar. Does the Thursday journal's editor know that Prof. Wanklyn was at one time Prof. Dewar's tutor?

Turning down Electric Lights.—Mr. T. B. Sharp, of County Chambers, Birmingham, proposes to regulate the brilliancy of incandescent lamps by placing in circuit a revolving commutator with alternate conducting and insulating blades, and a brush which is movable by the handle of the regulator. The conducting blades and insulators are V Λ-shaped, fitted close together, so that if the brush is on the broad end of the conducting blades, the current drawn from the revolving commutator is continuous, and the lights full up, but if we slide the brush along the current becomes broken as the insulating V's come under it, and we can go on reducing the light to a minimum when the brush is over the broad end of the insulating and narrow end of the conducting V's. Several very obvious objections to such a method occur to us. First, the spark at the commutator as the brush breaks the circuit at full pressure must be very destructive. These sparks must occur at the rate of 30 to 40 per second, and go on all the time the lights are on. Next, unless a commutator driven by some motive power is connected to each light, the control of each lamp is lost, and we are afraid the cost of a motor and commutator would be too much to add to an incandescent light. If used for a group, or a whole installation, the cost would not be so serious, but the breaking of a large current so frequently as is necessary would destroy in a few days the best rotating commutator ever designed. This proposal does not by any means solve the problem of turning down lights any better than a simple resistance; resistances are expensive, but motors and commutators are more so.

Evening Classes.—We have received a calendar of the evening classes to be held at the People's Palace during the 1894-5 session. Mr. A. G. Cooke, M.A., is the lecturer in the electrical department, and he is assisted by Messrs. Mansbridge and Shaughnesy.

The Cologne Express Accident.—Among the injured passengers in the Cologne express were M. Pulsford (electrical engineer, of Paris), and his wife, each of whom has a leg broken.

"The New Gas."—In scientific circles on the Continent the discovery of "a new constituent" in the atmosphere by Lord Rayleigh and Prof. William Ramsay has been received with anything but the respectful, and withal, sad silence which has been its mede very generally here. It has been attacked violently by the Germans, and laughed out of court by the French. Such an opportunity was not to be missed by our contemporaries across the channel, and even *Le Journal Amusant* last week sacrificed half a page of its, to speak euphemistically, customary Rabelaisian humour, to a gibe on what it facetiously terms "Oxfordgen"!

Electrolysis in the Production of Nickel and Cobalt.—The future of the metal cobalt is still uncertain, but there is no doubt that nickel has now obtained an important place amongst the useful metals. Whilst 1,000 tons flooded the market a few years ago, about eight times this quantity is now consumed in a year, chiefly in the production of nickel-steel and nickel-copper. We do not imagine that either nickel or cobalt will ever be produced in very large quantities by wet methods of electrolysis; but since for some purposes, which are increasing in importance year by year, it is desirable to have these metals in their purest state, there is little doubt that the advantages offered by electrolytic processes will be recognised. Recently C. Hoepfner has devised a method of this kind using solutions of the metals, these solutions being either neutral or slightly acidulated with citric or phosphoric acids. These solutions are placed next cathodes, which either rotate or oscillate, and are pounded with brushes or rubbing cushions: whilst next the anode, which may be soluble or insoluble, is placed a solution of some electro-positive metal, such as the chlorides of sodium, potassium, or calcium. An insoluble anode may be replaced in this process by a soluble one such as zinc, which is more electro-positive than cobalt or nickel. In the plant which has been designed for this process a remarkable feature is the use of membranes between the electrodes, made of "nitro-cellulose," "nitro-linen," and "nitro-cloth," which are sometimes mixed with asbestos, but are in every case backed on the cathode side by an open grating or sieve. Hoepfner proposes to obtain zinc, lead, tin, and copper by this process.

Lightning Statistics.—An American exchange states that a Government publication places the deaths by lightning in the United States for 1893 at 209, and in 1892 at 251. In the eight years to 1893, 3,516 fires were caused by lightning. In Massachusetts the following tabulation shows the year, number killed by lightning, and the fires from the same cause:—

Year.	No. killed.	Fires caused.	Year.	No. killed.	Fires caused.	Year.	No. killed.	Fires caused.
1892	10	65	1891	—	31	1890	6	45
1889	4	25	1888	3	42	1887	1	47
1886	7	28	1885	4	37	1884	3	29

It will thus be seen that although the number of deaths and fires by lightning has not decreased, there seems to be no regular increment of the danger. In 1884 there were three deaths and 29 fires, in 1887 one death and 47 fires, while in 1891 there were no deaths, but 31 fires. Our contemporary does not argue that these figures prove absolutely the fact, but they tend to disprove the assertion that the increased mileage of electric street railway wires and tracks is responsible for the lightning that from time to time kills cows and ignites haystacks many miles from an electric railway track. The year 1893 was singularly free from destruction of life and property by fire, although the official reports have not yet been published. It seems, therefore, that the ancient superstition relative to the conductivity of rails and wires as a path for thunderstorms must pass into the limbo of exploded popular opinions, where may be found the deadly trolley fabrication and the car-starter idea.

A New Thermostatic Instrument.—It may be said of the devices for giving an alarm when temperature becomes excessive, as in the case of fire, that "their name is legion;" and in many of them, too, the points of difference are extremely slight. A new thermostatic instrument, which has recently been perfected in America by G. W. Gregory, presents a certain degree of novelty. It is intended for use in an electric circuit. In its essentials the apparatus consists of a capsule containing a volatile liquid, which is fastened to a strong non-conducting base, and is connected to the terminals of an electric circuit containing an alarm bell by means of strips of fusible metal passing through the base. When the temperature rises to any determined limit, the volatile liquid expands within the capsule, and by means of an ingenious device is able to force the capsule away from its base. In so doing, the fusible metal connections, being soft, are ruptured, the electric circuit is broken, and the alarm is given. Should the capsule fail to rupture the connections in the manner described, a slight increase of temperature will effect it, and so break the circuit.

A Magnetic Dielectric.—It is about two years ago since it was demonstrated, by means of conclusive experiments, that the "Hertz" waves, which are propagated along a wire, magnetise transversely the shell, the thickness of which probably does not exceed some thousandths of a millimetre, in which the alternating current travels. When once it was proved that it was possible to produce alternating magnetisations of equal rapidity, other questions presented themselves, for example, the possibility of obtaining evidence of the existence in magnetic cylinders of stationary magnetic waves, analagous to the stationary electric waves, which can be set up in metallic wires. However, it is scarcely probable that iron can serve as a material for transmitting such waves, the conductivity of the metal preventing its magnetic properties from manifesting themselves sufficiently. And experiment supports this conclusion. Mons. Birkeland has consequently sought for some other magnetic material which does not conduct so well as iron into which magnetic inductions may be able to penetrate sufficiently deeply. This material was obtained by mixing solid paraffin with chemically reduced iron, the latter being in the form of an impalpable powder, a quantity of finely powdered quartz being also added. The suggestive name of "ferro-paraffin" has been given to this mixture, which proved to be a most satisfactory magnetic dielectric. Mons. Birkeland has proved experimentally that magnetisation penetrates easily to a depth of 7 mm. into ferro-paraffin which contains 10 per cent. of iron, and even to a depth of 5 mm. when the percentage is increased to 25. The material thus conforms to the conception of Poisson-Morotti. A number of experiments are described by Mons. Birkeland in the *Comptes Rendus*, Vol. cxviii., p. 1,320, which seem to promise that more extensive researches would result in some interesting if not important discoveries.

NEW COMPANIES REGISTERED.

F. E. Baron & Co., Limited (41,880).—This company was registered on the 1st inst. with a capital of £6,000 in £1 shares (1,500 preference and 4,500 ordinary), to acquire and carry on the business now carried on at the Hampton Wick Ironworks, under the style of F. E. Baron & Co., and to follow the trades of general and electrical engineers, &c. The subscribers are:—F. E. Baron, Hampton Wick, engineer, 1 share; H. W. A. Keyl, 71, Alexandra Road, South Hampstead, gentleman, 4 shares; H. Symonds, Hampton Wick, clerk, 1 share; P. H. Bettle, Hampton Wick, engineer, 1 share; C. G. Baron, Ponder's End, chartered accountant, 1 share; R. Peake, 6, Bedford Row, W.C., solicitor, 1 share; H. P. Scatiff, 33, Whitehead Grove, S.W., solicitor, 1 share. The first directors are Messrs. F. E. Baron and H. W. A. Keyl; remuneration 10s. for each attendance at a board meeting. Registered by Peake & Co., 6, Bedford Row, E.C.

Hampstead General Electric Fitting Company, Limited (41,911).—This company was registered on the

6th inst. with a capital of £1,000, in £1 shares, to carry on the businesses of civil, mechanical, sanitary, gas, water, electrical, and general engineers, and also of manufacturers of, and dealers in, all kinds of machinery, fittings, &c., relating to the above businesses. The subscribers (with one share each) are:—P. C. Gilchrist, Frognal Bank, Finchley Road, N.W., metallurgist; N. A. M. Gilchrist, Frognal Bank, Finchley Road, N.W., married woman; W. W. Roff, 40A, Downshire Hill, N.W., builder; W. H. Roff, 89, Heath Street, N.W., builder; O. H. Stovell, 1, Louis Villas, Child's Hill, carpenter; R. H. Hoare, 7, Sussex Gardens, W., clerk; G. Thomson, 122, Calabria Road, N., clerk. The first directors are P. C. Gilchrist and W. W. Roff; remuneration to be fixed in general meeting. Registered by J. E. Wilson, 21, Cornhill, E.C.

Liquor Register Syndicate, Limited (41,914).—This company was registered on the 7th inst. with a capital of £18,000, in £1 shares, to acquire letters patent, inventions, &c., and to carry on the business of electricians, mechanical engineers, suppliers of electricity, and manufacturers of, and dealers in, mechanical and electrical appliances. The subscribers (with one share each) are: A. Warnes, 16, Red Lion Street, E.C., engineer; W. Crawley, 16, Red Lion Street, E.C., engineer; E. J. Ferguson, 16, Red Lion Street, E.C., clerk; C. F. Wilkins, 8, Wolseley Gardens, Chiswick, electrician; A. D. Hughson, 51, Wightman Road, Harringay, engineer; E. G. Saunders, Barnes, gentleman; E. H. May, 2, Belsize Park Gardens, N.W., gentleman. Many of the regulations of Table "A" apply. Registered by W. J. Payne, 11, Queen Victoria Street, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Oswestry Electric Lighting and Power Company Limited (38,303).—This company filed its yearly return on the 5th ult., which shows that out of a capital of £10,000 in £1 shares, 14 shares have been taken up. Nothing has been called or paid.

Keighley Electrical Engineering Company, Limited (35,485).—This company filed its yearly return on July 23rd last. It shows that out of a nominal capital of £10,000, in £1 shares, 4,083 shares have been taken up, and that the full amount has been called on 728 shares. A sum of £728 has been received; £3,300 has been agreed to be considered as paid, and £55 is outstanding.

African Direct Telegraph Company, Limited (21,895).—This company's yearly return, filed on the 1st inst., shows that out of a capital of £300,000 in £10 shares, 23,600 shares have been taken up, and that the full amount has been called on each. The total sum received is, therefore, £236,000.

Ecuador Telephone Company, Limited (29,295).—This company's last annual return shows that out of a nominal capital of £100,000, in £5 shares, 5,000 shares have been taken up, and that £5 has been called on each. The total received is £25,000.

Akester Electro-Motor and Accumulator Company, Limited (24,431).—This company's last yearly return shows that out of a nominal capital of £5,000, in £1 shares, 4,348 shares have been taken up, and that £1 has been called on each. The total received is £1,324 12s.; £3,500 has been agreed to be considered as paid; £175 8s. is outstanding; and £475 12s. has been paid on 652 forfeited shares.

Electric Semaphore Signal Syndicate, Limited (38,360).—The secretary of the above concern writes the Registrar of Joint Stock Companies that the directors never proceeded to allotment, and that they do not propose to file any further return.

Edison & Swan United Electric Light Company, Limited (18,984).—This company's yearly return, filed on the 14th ult., shows that out of a nominal capital of £1,000,000, in 150,000 "A" and 50,000 "B" £5 shares, 89,261 "A" £3 paid, 17,139 "A" fully paid, and 23,564 "B" fully paid shares have been taken up, and that 10s. has been called on 89,261 shares. A sum of £44,630 10s. has been received, and £471,298 has been agreed to be considered as paid.

Railway Electric Reading Lamp Company, Limited (36,749).—The annual return of this company shows that out of a nominal capital of £100,000, in £5 shares, seven shares only have been taken up, and that nothing has been called or paid.

Electrical Company, Limited (36,819).—On August 15th last this company filed its annual return, which shows that out of a nominal capital of £15,000, in £5 shares, the whole of the shares have been taken up, and that £1 has been called on each. A sum of £3,000 has been received in response to calls, and £9,000 has been agreed to be considered as paid.

Exchange Telegraph Company, Limited (6,152 C).—This company's yearly return, filed on the 18th ult., shows that out of a nominal capital of £246,250, in 8,125 "A" and 16,500 "B" shares, all of £10 each, the whole of the former and 16,200 of the latter class have been taken up. There has been £9 called on each of 6,000 "A" shares, and £1 on each of the remaining 2,125 "A" shares. The total received is £56,023; £179,000 has been agreed to be considered as paid, and £102 is outstanding.

Roger Dawson, Limited (37,901).—The registered office of this company is now at 63, Berner's Street, Oxford Street, W.

Electrical Power Storage Company, Limited (30,313).—This company's yearly return, filed August 15th, 1894, shows that out of a nominal capital of £100,500, in 100 founders' and 20,000 ordinary shares, all of £5 each, 18,257 ordinary and 66 founders' shares have been taken up. The full amount has been called on each of the founders', and £3 on each of 3,137 ordinary shares. The total sum received equals £9,386 15s. 7d.; £75,600 has been agreed to be considered as paid; £354 4s. 5d. is outstanding; and £400 is the amount paid on 404 ordinary which have been forfeited.

Blakey Emmott & Co., Limited (23,120).—On June 15th last the Registrar of Joint Stock Companies was advised that the registered office of the company had been changed to Prudential Buildings, Park Row, Leeds.

Bernstein Electric Lamp Company, Limited (21,444).—This company's last return shows that out of a nominal capital of £100,000 in £10 shares, 2,814 shares have been taken up, and that the full amount (£28,140) has been called and paid.

Crompton & Co., Limited (27,200).—This company's last return, filed on the 4th inst., shows that out of a nominal capital of £300,000, in £5 shares (30,000 preference and an equal number of ordinary), 28,180 preference and 9,928 ordinary shares have been taken up, that the full amount has been called on each of the former class, and £1 on each of 1,928 of the latter. A total of £142,819 has been received; £40,000 has been agreed to be considered as paid; and £33 is outstanding.

The following resolution has been lately passed and confirmed:—"That the capital of the company be reduced from £300,000 to £280,000 by cancelling paid up capital which has been lost, or is unrepresented by available assets, to the extent of £20,000, by cancelling 4,000 ordinary fully paid up shares of the company, numbered 2,785 to 6,784 inclusive, which have been issued." A document to this effect was filed at Somerset House on the 4th inst.

American Insulated Wire Company, Limited (36,866).—Messrs. J. & H. Gregory, Leslie & Hartley, of 15, Union Court, Castle Street, Liverpool, inform the Registrar of Joint Stock Companies that the above-named concern never made the purchase of any American business, and that it has never done any business of any kind. No shares have ever been issued.

Atlas Carbon Manufacturing Company, Limited (34,857).—This company's return was filed a short time since at Somerset House. It shows that out of a nominal capital of £2,000, in £1 shares, the whole of the shares have been taken up, and that £1,993 has been agreed to be considered as paid. Nothing has been called on the remaining 7 shares.

British Volta Electric Glow Lamp Company, Limited (39,507).—This company's last return shows that out of a nominal capital of £2,000 in £1 shares, 542 shares have been taken up, and that 6s. has been called on each of 142 of these. The sum received is £36 13s., £400 has been agreed to be considered as paid, and £5 19s. is outstanding.

Bicester Electricity Supply Company, Limited (35,109).—Mr. E. F. Tanner, solicitor, of Bicester, informs the Registrar of Joint Stock Companies that the above concern did not proceed to allotment, in consequence of insufficient capital being subscribed.

Chili Telephone Company, Limited (29,252).—This company's annual return was filed on the 18th ult., and shows that out of a nominal capital of £250,000, in £5 shares, 44,000 shares have been taken up, and that the full amount has been called and paid on each. The total received is, therefore, £220,000.

Allen, Everitt & Sons, Limited (31,632).—This company's registered office is now situated at Kingston Metal Works, Smethwick, near Birmingham.

CITY NOTES.

The Electric Construction Company, Limited.

The first general meeting of this company was held at Cannon Street Hotel, yesterday. Sir Daniel Cooper's (the chairman) address to the shareholders was as follows: Before you can form a sound opinion on the accounts which the directors have the pleasure of submitting to you, it is necessary that I should briefly give you some idea of the troubles and difficulties the directors have had to deal with and overcome in the past year. As you are aware, the old company was successfully reconstructed last year, but, besides the work of reconstruction, the board and the managing director had to deal with several entanglements that had to be taken over as a legacy from the old corporation. These matters have been dealt with and, if not completely straightened out, are now in a comparatively narrow compass. In the end of December the heads of three important departments at Bushbury resigned on one month's notice, without any intelligible cause, and would not be induced to stay a short time longer till their places could be conveniently filled by others. At the same time Mr. Parker, the works' director, intimated to the board that he would not renew his engagement, which was to expire in the coming May. The board had no desire to retain him as works' director, but they were willing to keep up his connection with the company, and offered him a very liberal retaining fee as consulting engineer. This Mr. Parker declined to accept. About this time rumours became very prevalent that rival works were about to be built at Wolverhampton, but Mr. Parker strenuously denied that he had anything to do with them. Under these circumstances immediate steps had to be taken to reorganise the establishment, and in April it was found expedient to anticipate the termination of Mr. Parker's engagement by dispensing with his services. Now that the staff has been reorganised, the board are not sorry that the changes have been made, because they have secured a chief engineer and a technical staff at Bushbury in whose ability and loyalty they have full confidence; but you will understand that such extensive changes could not be made without seriously interrupting the work in hand and the continuous flow of new orders, and that these explanations were necessary before you could come to a just conclusion respecting the accounts submitted to you. I will now deal briefly with the accounts, which I am happy to think do not seem to require much explanation. And first, as respects the profit and loss account, I cannot say that I am satisfied, although it is quite as good as could be expected under the circumstances already explained. A good deal owing to the depression of business, but perhaps more to the reasons to which I have referred, the profits at Bushbury are too small, and the general expenses too large. I hope we shall be able to show you next year an improvement in both respects. The item of profit—£15,764 10s.—on sales of shares and debentures of other companies, requires some explanation. If you will refer to the balance-sheet you will observe an asset under the head of shares and debentures of other companies—£147,872 6s. 7d. These interests in other companies were valued by the directors, when taken over from the old company, according to the best of their judgment. They had great difficulty in arriving at what they considered a fair valuation, because none of the securities had market quotations. After much deliberation the prices fixed were such as were considered safe, but, at the same time, they could not then have been realised in the market. The values depended on the development of the undertakings. As it happened, the interests in certain of these properties matured more quickly than was anticipated, and the directors found an opportunity of realising them before the end of the financial year, with a profit of £15,764 10s.; this profit, less a proportion for general expenses, it is proposed to apply in reducing the amount at debit of this account, which will thus be strengthened by £12,500 to meet any unfavourable realisations, should such arise. Beyond the account—shares and debentures of other companies—I do not think there is any other item in the balance-sheet requiring explanation, but I shall be ready to answer any inquiries for further information. During the past year there has been extreme depression in business generally, and very keen competition in electric manufactures, but as you see from the report and accounts, we can fairly say that we have held our own. As to the future: I believe we have at Bushbury the finest electric works in the kingdom, and they are situated in a locality where work can be executed quite as economically as anywhere. Mr. Blackburn, the recently appointed chief engineer at Bushbury, has had wide experience in all kinds of electrical engineering, and is supported by a technical staff and a body of artisans at least equal to any other in the United Kingdom. All are determined to maintain the high character of the work hitherto turned out by our establishment, and we believe this can be done with greater economy than heretofore. The future, of course, depends to a large extent on the business activity not only in this, but in other countries which we supply with our manufactures. All I can say is we expect to obtain a fair share of what work is going, and to carry it out with reasonable profit to the shareholders. The business was never in so stable a position as it is to-day, and I do not think there is any cause to be apprehensive of the future. Before moving the formal resolution, I may add that a moderate increase of capital would be of advantage to the company. There remains of the £100,000 preference capital £74,010 unissued. The rate of dividend—7 per cent—we think too high, considering the improved position in which the company now stands, but there are various difficulties in the way of reducing the rate. A quotation on the Stock Exchange for the preference shares has been obtained, and, as we cannot redeem the portion issued, it would probably be impracticable to obtain another quotation for a new issue at a lower figure. The directors have come to no conclusion on the subject, but it is probable that they may resolve to offer the balance of the present preferred shares to the shareholders, giving ample time to pay up the calls, and thus the existing shareholders would receive, as they are well entitled to, the benefit of the high dividend payable on these preference shares. I now formally beg to move: "That the accounts and report, with the recommendations therein contained, now submitted by the directors, be approved and adopted."

Mr. Barclay seconded this, and upon the chairman inviting questions,

Mr. Williams (a shareholder) commented on the travelling expenses being high.

Other Shareholders wanted to know how they would be affected by Mr. Parker leaving them.

Mr. Cook asked whether the contingent liabilities in respect of calls might not seriously affect them.

Mr. Hancock spoke of the dispiriting state of affairs. After speaking of amounts they were led to expect from the E.P.S. Company, he passed on to the Parker episode. He considered that Mr. Parker had carried out most of the work with which the company had been connected. It was certainly Mr. Parker's ability which led him to put his money into the company.

Mr. Barclay replied on behalf of the directors. After dealing with the points raised by the speakers, he said that the board did not differ entirely with Mr. Hancock's remarks as to Mr. Parker's ability. Still, so far they were concerned, they had made a satisfactory change.

The re-election of directors and auditors was next proceeded with, and the meeting terminated.

Roper's Electrical Engineering Company, Limited.—Notice is given in the *London Gazette* that a general meeting of the above company will be held at the offices of Neill & Holland, 35, Hustlergate, Bradford, on October 15th, 1894, at 3 o'clock in the afternoon, for the purpose of having an account laid before them, showing the manner in which the winding up has been conducted, and the property of the company disposed of, and of hearing any explanation that may be given by the liquidator.

The Direct Spanish Telegraph Company, Limited.—The board have decided to recommend the payment of the dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend, free of income tax, of 1s. 8d. per share, being at the rate of 4 per cent. per annum on the capital paid up from the due date of payment on the ordinary shares of £5 each, both for the half-year ended June 30th, 1894.

City of Westminster Electrical Syndicate, Limited.—A meeting is to be held at 39, Eccleston Place, on October 17th, at 10 a.m., for the purpose of having laid before them an account of the winding up.

Commercial Cable Company.—A quarterly dividend of 1¾ per cent. has been declared, payable October 1st.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending September 9th, 1894, amounted to £840; week ending September 10th, 1893, £754; increase, £86; total receipts for half-year, 1894, £8,576; corresponding period, 1893, £8,148; increase, £428.

The Liverpool Overhead Railway Company. The traffic receipts for the week ending September 9th, 1894, amounted to £1,054; corresponding week last year, £724.

The Western and Brazilian Telegraph Company, **Limited. The receipts for the week ending** September 7th, after deducting **17 per cent. of the gross receipts payable to the London** Platino-**Brazilian Telegraph** Company, **Limited, were £2,887.**

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1891.	1892.	1893.	Closing Quotation September 5th.	Closing Quotation, September 12th.	Business done during week ended September 12th. 1894. Highest.	Lowest.
184,500£	African Direct Teleg., Ltd., 4 % Deb.	100	...	...	...	102 —105	102 —105	...	...
1,134,640£	Anglo-American Teleg., Ltd.	Stock	£2 12s.	£2 15s.	£2 11s.	41 — 44	40 — 43	...	...
2,932,680£	Do. do. 6 % Pref.	Stock	£5 5s.	£5 10s	£5 2s.	76 — 78	76 — 78	78¼	77
2,932,680£	Do. do. Defd.	Stock	...	...	...	7½ — 8	7 — 7½	7⅝	7 9/16
130,000	Brazilian Submarine Teleg., Ltd.	10	8 % §	6½% §	6½% §	12½ — 13	12½ — 13	13	12 13/16
75,000£	Do. do. 5 %, repayable June 1906	100	...	...	...	109 —113	109 —113	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 40,000	5	... §	10%‖ §	... §	1 — 2	1 — 2	...	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	139 —143	140 —145	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	3½% §	2 % §	2 % §	⅛ — ¼	⅛ — ¼	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	12 — 13 xd	12 — 13	...	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	19 — 20 xd	19 — 20	...	...
12,931	Direct Spanish Teleg., Ltd., £4 paid	5	4½%	4 %	4 %	4½ — 5	4½ — 5	...	...
6,000	Do. do. 10 % Pref.	5	10 %	10 %	10 %	9½ — 10	9½ — 10	...	...
30,000£	Do. do. 4½ % Debs. of £50, Nos. 1 to 1,600	...	...	...	...	105 —108%	105 —108%	...	...
60,710	Direct United States Cable, Ltd., 1877	20	3½% §	3½% §	...	8½ — 9½	9 — 9½	9¼	9⅛
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½% §	...	15⅞ — 16	15⅞ — 16	16	15⅞
70,000	Do. 6 % Pref.	10	6 % §	6 % §	...	16½ — 17	16⅛ — 17	16⅞	...
105,900£	Do. 5 % Debs., repay. August, 1899	100	...	...	...	106 —110	106 —110	...	...
1,294,100£	Do. 4 % Mort. Deb.	Stock	...	...	...	117 —120	117 —120	118½	...
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7 %	15⅞ — 16	15⅞ — 16	15 15/16	15⅝
62,700£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	...	...	...	103 —106	103 —106	...	...
222,800£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	...	...	...	103 —106	103 —106	...	...
320,000£	Do. 4 % Deb. Stock	Stock	...	...	...	115 —118	115 —118	...	...
95,100£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	...	...	...	103 —106	103 —106	...	...
129,100£	Do. do. do. to bearer, 2,344 to 5,500	...	...	...	...	103 —106	103 —106	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 2,016, red. 1909	100	...	...	...	103 —106	103 —106	104½	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	...	...	...	108 —111%	108 —111%	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	5½% §	4⅝% §	4⅝% §	8⅞ — 9⅛	8⅞ — 9⅛	9⅛	9
180,042	Do. do. 6 % Pref.	10	6 % §	6 % §	6 % §	15½ — 16	15⅞ — 16¼	16⅛	15⅞
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅜% §	8⅜% §	8⅜%	20½ — 21½	20½ — 21½	21¼	20⅝
200,000£	Do. do. do. 5 % Debs.	100	...	...	...	103 —106 xd	103 —106	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	10 %	46 — 48	46 — 48	46	...
37,548	London Platino-Brazilian Teleg., Ltd.	10	...	...	...	5 — 7	5 — 7	...	...
100,000£	Do. do. 6 % Debs.	100	...	...	...	106 —109 xd	106 —109	...	...
15,000	Monte Video Teleph. Co., Ord., 1 to 15,000	5	...	...	...	¼ — ⅜	¼ — ⅜	...	...
28,000	Do. do. 6 % Pref., 1 to 28,000	5	...	...	...	1 — 2	1 — 2	...	...
494,597	National Teleph., Ltd., 1 to 438,984	5	6 % §	5 % §	...	4⅞ — 5⅛	4⅞ — 5⅛	5 1/16	4 15/16
15,000	Do. 6 % Cum. 1st Pref.	10	...	...	...	14 — 15	14½ — 15½	15	14⅝
15,000	Do. 6 % Cum. 2nd Pref.	10	...	...	...	13½ — 14½	14 — 15	14⅜	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 90,950	5	...	...	...	5⅛ — 5⅜	5⅛ — 5⅜	5 1/16	...
925,017£	Do. 4½ % Deb. Stock Prov. Certs. ...	...	...	...	...	108 —111	109 —112	111	...
48,800	New Teleph., Ltd., 25,901 to 74,700; £4 paid	10	...	...	...	... ...	... ...	...	...
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	...	...	½ — ⅝	½ — ⅝	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	...	...	...	104 —107	104 —107	106	...
11,839	Reuter's Ltd.	8	5 %	5 %	...	3 — 5	3 — 5	...	...
3,381	Submarine Cables Trust	Cert.	...	...	...	107 —112	107 —112	109	108
58,000	United River Plate Teleph., Ltd.	5	...	...	...	1½ — 2⅛	1½ — 2⅛	2⅛	...
146,370£	Do. do. 5 % Debs.	Stock	...	...	...	88 — 94	88 — 94	90	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	4 %	..	...	3 — 5	3 — 5	...	...
249,900£	Do. do. do. 5 % Debs.	100	...	...	...	100 —103 xd	100 —103	102	100
30,000	West Coast of America Teleg., Ltd.	10	...	...	...	2 — 3	2 — 3	...	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	...	...	...	100 —105	100 —105	103½	...
64,242	Western and Brazilian Teleg., Ltd.	15	4 %	2½%	5 %	7¼ — 7¾	7⅞ — 8¼	8	7⅞
33,129	Do. do. do. 5 % Cum. Pref. ...	7½	...	...	...	6 — 6½	6 — 6⅜	6¼	6 3/16
33,129	Do. do. do. 5 % Def.	7½	3 %	...	...	2 — 2½	2¼ — 2⅜	2⅜	2⅜
178,200£	Do. do. do. 6 % Debs. "A," 1910 ...	100	...	...	...	106 —109	106 —109	...	...
222,700£	Do. 6 % Mort. Debs., series "B," red. Feb. 1910	100	...	...	...	106 —109	106 —109	...	...
88,321	West India and Panama Teleg., Ltd.	10	¼%	¼%	⅜%	1¼ — 1½	1½ — 1½	1⅝	1 5/16
34,563	Do. do. do. 6 % 1st Pref. ...	10	...	...	...	10½ — 11	10½ — 11	10⅝	10½
4,669	Do. do. do. 6 % 2nd Pref. ...	10	...	...	..	9 — 10	9 — 10	9⅝	...
80,000£	Do. do. 5 % Debs. (1917) No. 1 to 1,000	100	...	...	...	107 —110	108 —111	...	...
$1,214,000	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	...	...	...	115 —120	115 —120	...	...
169,000£	Do. do. 6 % Ster. Bonds.	100	...	...	...	100 —103 xd	100 —103	...	...

ELECTRICITY SUPPLY COMPANIES.

20,510	Charing Cross and Strand Electy. Supply, 1 to 6, 215 to 718, and 10,001 to 30,000	5	...	5 %	4½%	4½ — 5½	4½ — 5½	4 15/16	4¾
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	...	...	12½ — 13½	12½ — 13½	13½	13½
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	...	6 %	6 %	14¼ — 14¾	14¼ — 14¾	14⅝	14 7/16
100,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	...	...	...	129 —132	129 —132	...	...
50,000	†Liverpool Electric Supply, £4 10s. paid	5	4½%	5 %	5 %	6¾ — 7 xd	6¾ — 7	6⅞	...
49,900	*Metropolitan Electric Supply, Ltd., 6,101 to 50,000 ...	10	1 %	2 %	2½%	8½ — 9	9¼ — 9¾	9¾	9
100,000£	Do. 5% Deb., 1 to 10,000 in bonds of £10, £20, £40	...	...	...	...	... — ...	... — ...	...	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	...	...	4½ — 5½	4½ — 5½	...	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-18,780	5	8½%	7½%	4½%	7 — 7⅛	6¾ — 7⅛	...	...
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	8¼ — 8⅜	8¼ — 9	8⅜	8⅛
59,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	...	3½%	4 %	6¼ — 6⅜	6¼ — 6⅜	6 1/16	6 1/16

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital.

Dividends marked § are for a year consisting of the latter part of year and the part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1891.	1892.	1893.	Closing Quotation, Sept. 5th.	Closing Quotation, Sept. 12th.	Business done during week ended Sept. 12th, 1894. Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000	3	...	6 % §	6 % §	2⅞ — 3⅛	2⅞ — 3⅛	3 1/16	2⅞
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	...	6 % §	6 % §	2⅜ — 2⅝	2⅜ — 2⅝	2⅝	2½
125,000/	Do. do. 4½ % Deb.	Stock	...	...	...	109 —112 xd	109 —112	110½	...
630,000/	City and South London Railway	Stock	...	⅝%	⅝%	36 — 38	36 — 38	37½	...
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	7 % §	7 % §	7 % §	1⅜ — 2¼	1⅜ — 2¼	...	...
50,000/	Do. do. 5 % 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	...	...	...	95 —100	95 —100	...	...
120,000	Electric Construction, Ltd., 1 to 120,000	2	...	...	...	⅛ — ⅜	⅛ — ⅜	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	...	...	...	1½ — 2	1⅝ — 2¼	...	...
100,000	Elmore's French Patent Cop. Deposg., Ltd, 1 to 66,750 ...	2	*nil*	*nil*	*nil*	1/32 — 3/32	1/32 — 3/32	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil* ¶	*nil*	*nil*	1⅛ — 1⅜	1⅛ — 1⅜	1⅜	1 7/16
67,385	Elmore's Wire Mfg., Ltd., 1 to 67,385, issued at 1 pm. ...	2	*nil*	*nil*	*nil*	1 — 1⅛	1⅛ — 1⅜	1 5/16	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300	5	*nil* §	*nil* §	*nil* §	½ — 1½	½ — 1½	...	...
9,600/	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	7 %	...	...	6½ — 7½	6½ — 7½	...	...
6,837	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	5 %	5 %	7½ — 8½	7½ — 8½	...	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	12½%	12½%	23½ — 24½	23½ — 24½	24	23¾
200,000	Do. do. do. 4½ % Deb., 1896	100	...	...	...	104 —105	104 —106	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	...	...	1 %	7½ — 7¾	7⅞ — 8⅛	8	7⅞
6,295	† Do. do. Pref., £8 paid	10	...	...	...	12¾ — 13	12¾ — 13	...	...
78,949	Swan United Electric Light, Ltd., £3½ paid	5	11 % §	10 % §	7½% §	... — ...	... — ...	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	20 %	15 %	20 %	40 — 42	40 — 42	42	41
150,000/	Do. do. do. 5 % Bonds, red. 1894	100	...	...	...	102—105	102 —105	...	...
54,000	Waterloo and City Railway, Nos. 1 to 54,000, £2 paid ...	10	...	...	...	2 — 2¼	2 — 2¼	2 3/16	2

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.
Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.
Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%§; 1891—7%§; 1890—8%§.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5¼—5⅜.
Electric Construction Corporation, 6 % Debentures, 87—92.
Electric and General Investment, shares of £5 (£1 paid), 1¾—2¼.
Electricity Supply Corporation, Ordinary of £5, 5—5¼.
House-to-House Company (£5 paid), 1—1½.
Do. do. 7 % Preference, of £5, 5¼—5½.
Do. do. 6 % Debentures of £100, 101—103.
Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 4¾—5¼; 1st Preference Cumulative 6 %, £5 (fully paid), 6¼—6⅜.
Liverpool Electric Supply, £5 (fully paid), 6⅜—6½.
Do. do. £3 10s. paid, 4⅛—4¼.
London Electric Supply Corporation, £5 Ordinary, ⅞—1¼.
Queen Anne's Mansions Lighting and Heating Company, 6 % £100 Debentures, 101—103.
Yorkshire House-to-House Electricity Company, £5 Ordinary Shares (£4 10s. paid), 4¼—4⅜.

Bank rate of discount, 2 per cent. (February 22nd, 1894).

THE BRITISH ASSOCIATION.

ON THE MINIMUM CURRENT AUDIBLE IN THE TELEPHONE.

By Lord Rayleigh, Sec.R.S.*

(*Read before Section A, August 13th.*)

The estimates which have been put forward of the minimum current perceptible in the Bell telephone vary largely. Mr. Preece gives 6×10^{-13} ampères†; Prof. Tait, for a current reversed 500 times per second, 2×10^{-12} ampères‡. De la Rue gives 1×10^{-8} ampères, and the same figure is recorded by Brough§ as applicable to the *strongest* current with which the instrument is worked. The only experimenter who has described his method with detail sufficient to allow of criticism is Prof. Ferraris‖, whose results may be thus expressed:—

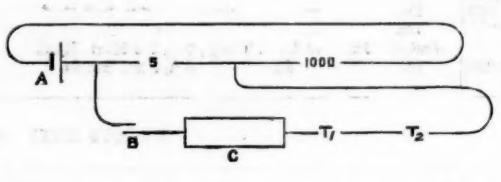
Pitch.	Frequency.	Minimum current in ampères.
Do_3	264	23×10^{-9}
Fa_3	352	17×10^{-9}
La_3	440	10×10^{-9}
Do_4	528	7×10^{-9}
Re_4	594	5×10^{-9}

The currents were from a make-and-break apparatus, and in each case are reckoned as if only the first periodic term of the Fourier series representative of the actual current were effective. On this account the quantities in the third column should probably be increased, for the presence of overtones could hardly fail to favour audibility.

Although a considerable margin must be allowed for varying pitch, varying acuteness of audition, and varying construction of the instruments, it is scarcely possible to suppose that all the results above mentioned can be correct, even in the roughest sense. The question is of considerable interest in connection with the theory of the telephone. For it appears that *a priori* calculations of the possible efficiency of the instrument are difficult to reconcile with numbers such as those of Tait and of Preece, at least without attributing to the ear a degree of sensitiveness to aerial vibration far surpassing even the marvellous estimates that have hitherto been given*.

Under these circumstances it appeared to be desirable to undertake fresh observations, in which regard should be paid to various sources of error that may have escaped attention in the earlier days of telephony. The importance of defining the resistance of the instruments and of employing pure tones of various pitch need not be insisted upon.

As regards resistance, a low resistance telephone, although suitable in certain cases, must not be expected to show the same sensitiveness to current as an instrument of higher resistance. If we suppose that the total space available for the windings is given, and that the portion of it occupied by the copper is also given, a simple relation obtains between the resistance and the minimum current. For if γ be the current, n be the number of convolutions, and r the resistance, we have as in the theory of galvanometers, $n\gamma = \text{const.}$, $n^2 r = \text{const.}$, so that $\gamma \sqrt{r} = \text{const.}$, or the minimum current is inversely *as the square root of the resistance.*



The telephones employed in the experiments about to be narrated were two, of which one (T_1) is a very efficient instrument of 70 ohms resistance. The other (T_2) of less finished workmanship, was rewound in the laboratory with comparatively thick wire. The interior diameter of the windings is 9 millim., and the exterior diameter is

* Communicated by the author.
† Brit. Assoc. Report, Manchester, 1887, p. 611.
‡ Edin. Proc., Vol. ix., p. 551 (1878). Prof. Tait speaks of a *billion* B.A. units, and, as he kindly informs me, a billion here means 10^{-12}.
§ Proceedings of the Asiatic Society of Bengal, 1877, p. 255.
‖ *Atti della R. Accad. d. Sci. di Torino*, Vol. xiii., p. 1,024 (1877).

* *Proc. Roy. Soc.*, Vol. xxvi., p. 248 (1877). Also Wien, Wied. *Ann.*, Vol. xxxvi., p. 834 (1889).

26 millim. The width of the groove, or the axial dimension of the coil, is 8 millim., the number of windings is 160, and the resistance is ·8 ohm. Since the dimensions of the coils are about the same in the two cases, we should expect, according to the above law, that about 10 times as much current would be required in T_2 as in T_1. Both instruments are of the Bell (unipolar) type, and comparison with other specimens shows that there is nothing exceptional in their sensibility.

In view of the immense discrepancies above recorded, it is evident that what is required is not so much accuracy of measurement as assured soundness in method. It appeared to me that electromotive forces of the necessary harmonic type would be best secured by the employment of a revolving magnet in the proximity of an inductor-coil of known construction. The electromotive force thus generated operates in a circuit of known resistance; and, if the self-induction can be neglected, the calculation of the current presents no difficulty. The sound as heard in the telephone may be reduced to the required point either by varying the distance (B) between the magnet and the inductor, or by increasing the resistance (R) of the circuit. In fact both these quantities may be varied; and the agreement of results obtained with widely different values of R constitutes an effective test of the legitimacy of neglecting self-induction. When R is too much reduced, the time constant of the circuit becomes comparable with the period of vibration, and the current is no longer increased in proportion to the reduction of R. This complication is most likely to occur when the pitch is high.

In order to keep as clear as possible of the complication due to self-induction, I employed in the earlier experiments a resistance coil of 100,000 ohms, constructed as usual of wire doubled upon itself. But it soon appeared that in avoiding Scylla I had fallen upon Charybdis. The first suspicion of something wrong arose from the observation that the sound was nearly as loud when the 100,000 ohms was included as when a 10,000-ohm coil was substituted for it. The first explanation that suggested itself was that the sound was being conveyed mechanically instead of electrically, as is indeed quite possible under certain conditions of experiment. But a careful observation of the effect of breaking the continuity of the leads, one at a time, proved that the propagation was really electrical. Subsequent inquiry showed that the anomaly was due to a condenser, or leyden jar, like action of the 100,000-ohm coil. When the junction at the middle was unsoldered, so as to interrupt the metallic continuity, the sounds heard in the telephone were nearly as loud as before. In this condition the resistance should have been enormous, and was in fact about 12 megohms* as indicated by a galvanometer. It was evident that the coil was acting principally as a leyden jar rather than as a resistance, and that any calculation founded upon results obtained with it would be entirely fallacious.

It is easy to form an estimate of the point at which the complication due to capacity would begin to manifest itself. Consider the case of a simple resistance, R, in parallel with a leyden jar of capacity, C, and let the currents in the two branches be x and y respectively. If V be the difference of potential at the common terminals, proportional to e^{ipt}, we have

$$x = V/R, \qquad y = C\,dV/dt = ipVC;$$

so that

$$\frac{x+y}{V} = \frac{1+ipRC}{R}.$$

The amplitude of the total current is increased by the leyden jar in the ratio $\sqrt{(1+p^2R^2C^2)} : 1$; and the action of the leyden jar becomes important when $pRC = 1$. With a frequency of 640, $p = 4{,}020$; so that, if $R = 10^{14}$ C.G.S., the critical value of C is $\frac{1}{402} \times 10^{-15}$ C.G.S., or about $\frac{1}{400}$ of a microfarad.

It will be seen that even if the capacity remained unaltered, a reduction of resistance in the ratio, say, of 10 to 1 would greatly diminish the complication due to condenser-like action; but perhaps the best evidence that the results obtained are not prejudiced in this manner is afforded by the experiments in which the principal resistance was a column of plumbago.

The revolving magnet was of clock-spring, about $2\frac{1}{2}$ centim. long, and so bent as to be driven directly, windmill fashion, from an organ bellows. It was mounted transversely upon a portion of a sewing needle, the terminals of which were carried in slight indentations at the ends of a U-shaped piece of brass. As fitted to the wind-trunk the axis of rotation was horizontal.

The inductor-coil, with its plane horizontal, was situated so that its centre was vertically below that of the magnet at distance B. Thus, if A be the mean radius of the coil, n the number of convolutions, the galvanometer constant G of the coil at the place occupied by the magnet is given by

$$G = \frac{2\pi n A^2}{C^3}, \qquad (1)$$

where $C^2 = A^2 + B^2$; and if m be the magnetic moment of the magnet, and ϕ the angle of rotation, the mutual potential M may be represented by†

$$M = G m \sin\phi. \qquad (2)$$

If the frequency of revolution be $p/2\pi$, $\phi = pt$; and then

$$dM/dt = G m p \cos pt. \qquad (3)$$

The expression (3) represents the electromotive force operative in the circuit. If the inductance can be neglected, the corresponding current is obtained on division of (3) by R, the total resistance of the circuit.

The moment, m, is deduced by observation of the deflection of a magnetometer-needle from the position which it assumes under the operation of the earth's horizontal force, H. If the magnet be situated to the east at distance, r, and be itself directed east and west, the angular deflection, θ, from equilibrium is given by

$$\tan\theta = \frac{2m}{Hr^3}.$$

The relation between the angle, θ, and the double deflection, d, in scale divisions, obtained on *reversal* of m, is approximately $\theta = d/4D$, where D is the distance between mirror and scale; so that we may take

$$m = \frac{H r^3 d}{8D}. \qquad (4)$$

The amplitude of the oscillatory current, generated under these conditions, is accordingly

$$\frac{n\pi p H A^2 r^3 d}{4 C^3 R D} \qquad (5)$$

If C.G.S. units are employed, H = ·18. A must of course be measured in centimetres; but any units that are convenient may be used for r and C, and for d and D. The current will then be given in terms of the C.G.S. unit, which is equal to 10 ampères.

The inductor coil used in most of the experiments is wound upon an ebonite ring, and is the one that was employed as the "suspended coil" in the determination of the electro-chemical equivalent of silver.* The number of convolutions (n) is 242. The axial dimension of the section is 1·4 centim., and the radial dimension is ·97 centim. The mean radius, A, is 10·25 centim., and the resistance is about $10\frac{1}{2}$ ohms.

In making the observations the current from the inductor coil was led to a distant part of the house by leads of doubled wire, and was there connected to the telephone and resistances. Among the latter was a plumbago resistance on Prof. F. J. Smith's plan† of about 84,000 ohms; but in most of the experiments a resistance box going up to 10,000 ohms was employed, with the advantage of allowing the adjustment of sound to be made by the observer at the telephone. The attempt to hit off the least possible sound was found to be very fatguing and unsatisfactory; and in all the results here recorded the sounds were adjusted so as to be *easily* audible after attention for a few seconds. Experiment showed that the resistances could then be *doubled* without losing the sound, although perhaps it would not be caught at once by an unprepared ear. But it must not be supposed that the observation admits of precision, at least without greater precautions than could well be taken. Much depends upon the state of the ear as regards fatigue, and upon freedom from external disturbance.

The pitch was determined before and after an observation by removing the added resistance and comparing the loud sound then heard with a harmonium. The *octave* thus estimated might be a little uncertain. It was verified by listening to the beats of the sound from the telephone and from a nearly unisonant tuning-fork, both sounds being nearly pure tones.

When the magnet was driven at full speed the frequency was found to be 307, and at this pitch a series of observations was made with various values of C and of R. Thus when B = 7·75 inches, or C = 8·7 inches, the resistance from the box required to produce the standard sound in telephone T_1 was 8,000 ohms, so that $R = 8{,}100 \times 10^9$. The quantities required for the calculation of (5) are as follows:—

$n = 242$,	$p = 2\pi \times 307$,	H = ·18,
A = 10·25,	$r = 8{\cdot}25$,	$d = 140$,
C = 8·7,	$R = 81 \times 10^{11}$,	D = 1,370,

r and C being reckoned in inches, d and D in scale-divisions of about $\frac{1}{40}$ inch. From these data the current required to produce the standard sound is found to be $7{\cdot}4 \times 10^{-8}$ C.G.S., or $7{\cdot}4 \times 10^{-7}$ ampères, for telephone, T_1.

The results obtained by the method of the revolving magnet are collected into the accompanying Table. The "wooden coil" is of smaller dimensions than the "ebonite coil," the mean radius being only 3·5 centim. The number of convolutions is 370.

Frequency = 307. Ebonite coil.

Telephone.	R in ohms.	Current in ampères.	Sound.
T_1	84,100 Plumbago.	$3{\cdot}8 \times 10^{-7}$	Below standard.
T_1	8,100 Box.	$7{\cdot}4 \times 10^{-7}$	Standard.
T_1	4,100 Box.	$5{\cdot}2 \times 10^{-7}$	
T_2	500 Box.	$1{\cdot}2 \times 10^{-5}$	
T_2	200 Box.	$1{\cdot}0 \times 10^{-5}$	

Frequency = 307. Wooden coil.

T_1	84,100 Plumbago.	$3{\cdot}6 \times 10^{-7}$	Standard.
T_1	10,100 Box.	$3{\cdot}7 \times 10^{-7}$	
T_1	1,600 Box.	$5{\cdot}4 \times 10^{-7}$	
T_2	350 Box.	$1{\cdot}1 \times 10^{-5}$	

Frequency = 192. Ebonite coil.

T_1	3,100 Box.	$2{\cdot}5 \times 10^{-6}$	Standard.

The method of the revolving magnet seemed to be quite satisfactory so far as it went, but it was desirable to extend the determinations to frequencies higher than could well be reached in this manner. For this purpose recourse was had to magnetised tuning-forks, vibrating with known amplitudes. If, for the moment, we suppose the magnetic poles to be concentrated at the extremities of the

* Doubtless the insulation between the wires should have been much higher.

† Maxwell, "Electricity and Magnetism," Vol. ii., § 700.

* *Phil. Trans.*, part ii., 1884, p. 421.

† *Phil. Mag.*, Vol. xxxv., p. 210 (1893).

prongs, a vibrating fork may be regarded as a simple magnet, fixed in position and direction, but of moment proportional to the instantaneous distance between the poles. Thus, if the magnetic axis pass perpendicularly through the centre of the mean plane of the inductor-coil, the situation is very similar to that obtaining in the case of the revolving magnet. The angle, ϕ, in (2), is no longer variable, but such that $\sin\phi = 1$ throughout. On the other hand, m varies harmonically. If l be the mean distance between the poles, 2β, the extreme arc from rest to rest traversed by each pole during the vibration, m_0, the mean magnetic moment,

$$m/m_0 = 1 + 2\beta/l \,.\, \sin pt,$$

and

$$dM/dt = G\, m_0 p \,.\, 2\beta/l \,.\, \cos pt. \qquad (6)$$

The formula corresponding to (5) is thus derived from it by simple introduction of the factor $2\beta/l$.

The forks were excited by bowing, and the observation of amplitude was effected by comparison with a finely divided scale under a magnifying-glass. It was convenient to observe the extreme end of a prong where the motion is greatest, but the double amplitude thus measured must be distinguished from 2β. In order to allow for the distance between the resultant poles and the extremities of the prongs, the measured amplitude was reduced in the ratio of 2 to 3. The observation of the magnetic moment at the magnetometer is not embarrassed by the diffusion of the free polarity.

In order to explain the determination more completely, I will give full details of an observation with a fork, c', of frequency 256. The distance, l, between the middles of the prongs was ·875 inch, and the double amplitude of the vibration at the end of one of the prongs was ·09 inch. Thus 2β is reckoned as ·06 inch. The inductor-coil was the ebonite coil already described, and the sound was judged to be of the standard distinctness when, for example, B = 15 inches or C = 15·5 inches, and the added resistance was 1,000 ohms, so that $R = 1{,}100 \times 10^9$. The quantities required for the computation of (5) as extended are,

$n = 242$	$p = 2\pi \times 256$,	$H = \cdot 18$,
$A = 10{\cdot}25$,	$\tau = 15$,	$d = 410$,
$C = 15{\cdot}5$,	$R = 11 \times 10^{11}$,	$D = 1{,}370$,
	$2\beta = \cdot 06$,	$l = \cdot 875$;

and they give for the current corresponding to the standard sound $9{\cdot}8 \times 10^{-8}$ C.G.S., or $9{\cdot}8 \times 10^{-7}$ ampères.

A summary of the results obtained with forks of pitch c, c', c'', g', c'', e''. g'' is annexed. As the pitch rose, the difficulties of observation increased, both on account of the less duration of the sound and of the smaller amplitudes available for measurement. In one observation with telephone T_2, at pitch c'', the resistance, estimated at 11 ohms, was that of the coil, telephone, and leads only. No trustworthy result was to be expected under such conditions, but the number is included in order to show how small was the influence of self-induction, even where it had every opportunity of manifesting itself,

Telephone.	R in ohms.	Current in ampères.
	$c = 128$.	
T_1	1,100	$2{\cdot}8 \times 10^{-5}$
	$c' = 256$.	
T_1	8,100 Box ...	$6{\cdot}8 \times 10^{-7}$
T_1	1,100	$9{\cdot}8 \times 10^{-7}$
T_2	500	... ... $1{\cdot}1 \times 10^{-5}$
	$e' = 320$.	
T_1	84,000 Plumb.	$3{\cdot}8 \times 10^{-7}$
T_1	6,100 Box ...	$2{\cdot}6 \times 10^{-7}$
T_1	1,600	$3{\cdot}1 \times 10^{-7}$
	$g' = 384$.	
T_1	84,000 Plumb.	$1{\cdot}4 \times 10^{-7}$
T_1	9,500 Box ...	$1{\cdot}6 \times 10^{-7}$
T_1	2,100	$1{\cdot}4 \times 10^{-7}$
T_1	900	$1{\cdot}7 \times 10^{-7}$
T_2	600	... ... $1{\cdot}9 \times 10^{-6}$
T_2	300	... ... $2{\cdot}2 \times 10^{-6}$
	$c'' = 512$.	
T_1	84,000 Plumb.	$8{\cdot}9 \times 10^{-8}$
T_1	9,000 Box ...	$4{\cdot}8 \times 10^{-8}$
T_1	3,600	$5{\cdot}2 \times 10^{-8}$
T_1	700	$8{\cdot}2 \times 10^{-8}$
T_2	11?... ...	... ... $5{\cdot}2 \times 10^{-6}$?
T_2	100 Box ...	... ... $1{\cdot}9 \times 10^{-6}$
T_2	300	... ... $1{\cdot}4 \times 10^{-6}$
T_2	500	... ... $2{\cdot}5 \times 10^{-6}$
T_2	900	... ... $2{\cdot}4 \times 10^{-6}$
	$e'' = 640$.	
T_1	84,000 Plumb.	$3{\cdot}8 \times 10^{-8}$
T_1	5,100 Box ...	$3{\cdot}8 \times 10^{-8}$
T_1	1,100	$5{\cdot}5 \times 10^{-8}$
	$g'' = 768$.	
T_1	84,000 Plumb.	$1{\cdot}1 \times 10^{-7}$
T_1	7,100 Box ...	$\cdot 9 \times 10^{-7}$
T_1	2,100	$1{\cdot}1 \times 10^{-7}$

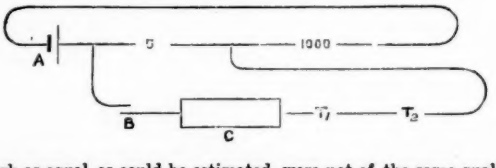
If we bring together the numbers* derived with the revolving magnet and with the forks, we obtain in the case of T_1:—

Pitch.	Source.	Current in 10^{-8} ampères.
128	Fork	2,800
192	Revolving magnet	250
256	Fork	83
307	Revolving magnet	49
320	Fork	32
384	... ...	15
512	... ...	7
640	... ...	4·4
768	... ...	10

It would appear that the maximum sensitiveness to current occurs in the region of frequency 640; but observations at still higher frequencies would be needed to establish this conclusion beyond doubt. Attention must be paid to the fact that the sounds were not the least that could be heard, and that before a comparison is made with the numbers given by other experimenters there should be a division by 2, if not by 3. But this consideration does not fully explain the difference between the above table and that of Ferraris already quoted, from which it appears that in his experiments a current of 5×10^{-9} ampères was audible.

It is interesting to note that the sensitiveness of the telephone to periodic currents is of the same order as that of the galvanometer of equal resistance to steady currents*, viz., that the currents (at pitch 512) just audible in the telephone would, on commutation, be just easily visible by a deflection in the latter instrument. But there is probably more room for further refinements in the galvanometer than in the telephone.

If we compare the performances of the two telephones, T_1 and T_2, we find ratios of sensitiveness to current ranging from 13 to 30; so that T_2 shows itself inferior in a degree beyond what may be accounted for by the resistances. It is singular that an experiment of another kind led to the opposite conclusion. The circuit of a Daniell cell, A, was permanently closed through resistance coils of 5 ohms and of 1,000 ohms. The two telephones in series with one another and with a resistance box, C, were placed in a derived circuit where was also a scraping contact apparatus, B, as indicated in the figure. The adjustment was made by varying the resistance in C until the sound was just easily audible in the telephone under trial. Experiments conducted upon this plan showed that T_1 was only about five times as sensitive to current as T_2. It was noticed, however, that the sounds,



though as equal as could be estimated, were not of the same quality, and in this probably lies the explanation of the discrepancy between the two methods of experimenting. In the latter the original sound is composite, and the telephone selects the most favourable elements —that is, those nearly in agreement with the natural pitch of its own plate. In this way the loudness of the selected sound becomes a question of the freedom of vibration of the plate, an element which is almost without influence when the sound is of pitch far removed from that of the proper tone of the telephone. There was independent reason for the suspicion that T_1 had not so well defined a proper pitch as was met with in the case of some other telephones.

P.S.—Measurements with the electro-dynamometer have been made by Cross and Page† of the currents used in practical telephony. The experiments were varied by the employment of several transmitters, and various vowel sounds were investigated. The currents found were of the order 2×10^{-4} ampères.

AN ATTEMPT AT A QUANTITATIVE THEORY OF THE TELEPHONE.

By Lord Rayleigh, Sec.R.S.‡

(*Read before Section A, August 13th.*)

The theory of the telephone cannot be said to be understood, in any but the most general manner, until it is possible to estimate from the data of construction what its sensitiveness should be, at least so far as to connect the magnitude of the vibratory current with the resulting condensations and rarefactions in the external ear passage. Unfortunately such an estimate is a matter of extreme difficulty, partly on account of imperfection in our knowledge of the magnetic properties of iron, and partly from mathematical difficulties arising from the particular forms employed in actual construction; and indeed the problem does not appear to have been attacked hitherto. In view, however, of the doubts that have been expressed as to theory, and of the highly discrepant estimates of actual sensitiveness which have been put forward, it appears desirable to make the attempt. It will be understood that at present the question is as to the order of magnitude only, and that the result will not be without value should it prove to be 10 or even 100 times in error.

One of the elements required to be known, the number (n) of convolutions, cannot be directly observed in the case of a finished instrument; but it may be inferred with sufficient accuracy for the present purpose from the dimensions and the *resistance* of the coil. Denote the axial dimension by ξ, the inner and outer radii by η_1 and η_2, the

* The observations recorded were made with my own ears. Mr. Gordon obtained very similar numbers when he took my place.

* See, for example, Ayrton, Mather and Sumpner, *Phil. Mag.*, Vol. xxx., p. 90, 1890, "On Galvanometers."

† Electrical Review, November 14th, 1885. I owe this reference to Mr. Swinburne.

‡ Communicated by the Author.

section of the wire by σ and its total length by l, so that $l\,\sigma$ is the total volume of copper. The area of section of the coil by an axial plane is $\xi\,(\eta_2 - \eta_1)$, and of this the area $n\,\sigma$ is occupied by copper. If we suppose the latter to be *half* the former, we shall not be far from the mark. Thus

$$n\,\sigma = \tfrac{1}{2}\,\xi\,(\eta_2 - \eta_1). \qquad (1)$$

On the same assumption,

$$l\,\sigma = \tfrac{1}{2}\,\pi\,\xi\,(\eta_2^2 - \eta_1^2). \qquad (2)$$

Accordingly, if R be the whole resistance of the coil, and r the specific resistance of copper,

$$\mathrm{R} = r\,\frac{l}{\sigma} = \frac{2\,\pi\,r\,n^2\,(\eta_2 + \eta_1)}{\xi\,(\eta_2 - \eta_1)}. \qquad (3)$$

As applicable to actual telephones we may take $\xi = 1$ centim., $\eta_2 = 3\,\eta_1$; and then $\mathrm{R} = 4\,\pi\,r\,n^2$. In C.G.S. measure $r = 1{,}600$, and thus

$$n^2 = \frac{\mathrm{R}}{4\,\pi\,\times\,1{,}600}. \qquad (4)$$

If the resistance be 100 ohms,

$$\mathrm{R} = 10^{11}, \text{ and } n = 2{,}230.$$

When the resistance varies, other circumstances remaining the same,

$$n \propto \sqrt{\mathrm{R}}.$$

We have now to connect the periodic force upon the telephone plate with the periodic current in the coil. As has already been stated, only a very rough estimate is possible *a priori*. We will commence by considering the case of an unlimited cylindrical core, divided by a transverse fracture into two parts, and encompassed by an infinite cylindrical magnetising coil containing n turns to the centimetre. If γ be the current, the magnetising force, $\delta\,\mathrm{H}$, due to it is

$$\delta\,\mathrm{H} = 4\,\pi\,n\,\gamma. \qquad (5)$$

If we regard the core as composed of soft iron, magnetised strongly by a constant force, H, the mechanical force with which the two parts attract one another per unit of area is in the usual notation

$$\mathrm{I}\,(\mathrm{H} + 2\,\pi\,\mathrm{I});$$

and what we require is the variation of this quantity, when H becomes $\mathrm{H} + \delta\,\mathrm{H}$. This may be written

$$\delta\,\mathrm{H}\left\{\mathrm{I} + (\mathrm{H} + 4\,\pi\,\mathrm{I})\,\frac{d\,\mathrm{I}}{d\,\mathrm{H}}\right\} \qquad (6)$$

The value of $d\,\mathrm{I}/d\,\mathrm{H}$ to be here employed is that appropriate to small cyclical changes. It is greatest when I is small, and then* amounts to about $100/4\,\pi$. As I increases, $d\mathrm{I}/d\mathrm{H}$ diminishes, and finally approaches to zero in the state of saturation. In order to increase (6) it is thus advisable to augment I up to a certain point, but not to approach saturation so nearly as to bring about a great diminution in the value of $d\,\mathrm{I}/d\,\mathrm{H}$. In the absence of precise information we may estimate that the maximum of (6) will be reached when I is about half the saturation value, or equal to 800†; and that $d\,\mathrm{I}/d\,\mathrm{H}$ also has half its maximum value, or $50/4\,\pi$. At this rate the force due to $\delta\,\mathrm{H}$ is about 40,000 $\delta\,\mathrm{H}$, reckoned per unit of area of the divided core, or by (5)

$$40{,}000\,\times\,4\,\pi\,n\,\gamma. \qquad (7)$$

But before (7) can be applied to the core of a telephone electromagnet it must be subjected to large deductions. For in the telephone the total number of windings, n, is limited to about one centimetre measured parallel to the axis, whereas in (7) the electromagnet is supposed to be infinitely long, and n denotes the number of windings per centimetre. If we are to suppose in (7) that the windings are really limited to one centimetre, lying immediately on one side of the division, there must be a loss of effect which I estimate at five times. We have now further to imagine the second part of the divided cylinder to be replaced by the plate of the telephone, and that not in actual contact with the remaining cylindrical part. The reduction of effect on this account I estimate at four times.‡

The force on the telephone plate per unit area of core is thus

$$2{,}000\,\times\,4\,\pi\,n\,\gamma; \qquad (8)$$

or if, as for the telephone of 100-ohms resistance, $n = 2{,}200$, and area of section = ·31 sq. cm.,

$$\text{force} = 1{\cdot}7\,\times\,10^7\,\gamma \qquad (9)$$

In (9) the force is in dynes, and the current, γ, is in C.G.S. measure. If Γ denote the current reckoned in ampères,

$$\text{force} = 1{\cdot}7\,\times\,10^6\,\Gamma, \qquad (10)$$

and this must be supposed to be operative at the centre of the plate.

We shall presently consider what effect such a force may be expected to produce; but before proceeding to this I may record the result of some experiments directed to check the applicability of (10), and made subsequently to the theoretical estimates. A Bell telephone, similar to $\mathrm{T_1}$, was mounted vertically, mouth downwards, having attached to the centre of its plate a slender strip of glass. This strip was also vertical and carried at its lower end a small scale-pan. The whole weight of the attachments was only ·44 gram. The movement of the glass strip in the direction of its length was observed through a reading microscope focussed upon accidental markings. The telephone, itself of 70 ohms resistance, was connected through a reversing-key with a Daniell cell and with an external resistance varied from time to time. In taking an observation the current was first sent in such a direction as to depress the plate, and the web was adjusted upon the mark. The current was then reversed, by which the plate was drawn up, but by addition of weights in the pan it was brought back again to the *same* position as before. The force due to the current is thus measured by the *half* of the weight applied.

The results were as follows:—

External resistance in ohms	...	...	100	200	500
Weight in grammes	...	...	8	4	2

When 1,000 ohms were included, the displacement on reversal was still just visible. We may conclude that a force of 1 gramme weight corresponds to a current of about $\frac{1}{800}$th of an ampere. Now, 1 gramme weight is equal to 981 dynes, so that for comparison with (10)

$$\text{force} = \cdot6\,\times\,10^6\,\Gamma. \qquad (11)$$

The force observed is thus about the third part of that which had been estimated, and the agreement is sufficient.

Although not needed for the above comparison, we shall presently require to know the linear displacement of the centre of the telephone plate due to a given force. Observations with the aid of a micrometer eyepiece showed that a force of of 5 grammes weight gave a displacement of $10^{-4}\,\times\,6{\cdot}62$ centim., or $10^{-4}\,\times\,1{\cdot}32$ for each gramme, viz., $10^{-7}\,\times\,1{\cdot}34$ centim. per dyne. Thus by (11) the displacement, x, due to a current, Γ, expressed in ampères, is

$$x = \cdot080\,\Gamma. \qquad (12)$$

We have now to estimate what motion of the telephone plate may be expected to result from a given periodic force operating at its centre. The effect depends largely upon the relation between the frequency of the imposed vibration and those natural to the plate regarded as a freely vibrating body. If we attempt to calculate the natural frequencies *a priori*, we are met by uncertainty as to the precise mechanical conditions. From the manner in which a telephone plate is supported, we should naturally regard the ideal condition as one in which the whole of the circular boundary is *clamped*. On this basis a calculation may be made, and it appears* that the frequency of the gravest symmetrical mode should be about 991 in the case of the telephone in question. But it may well be doubted whether we are justified in assuming that the clamping is complete, and any relaxation tells in the direction of a lowered frequency. A more trustworthy conclusion may perhaps be founded upon the observed connection between displacement and force of restitution, coupled with an estimate of the inertia of the moving parts. The total weight of the plate is 3·4 grams; the outside diameter is 5·7 centim., and the inside diameter, corresponding to the free portion of the plate, is 4·5. The effective mass, supposed to be situated at the centre, I estimate to be that corresponding to a diameter of 2·5 centim., viz., ·65 gram. A force of restitution per unit displacement equal to $(10^{-7}\,\times\,1{\cdot}34)^{-1}$, or $10^6\,\times\,7{\cdot}5$, is supposed to urge the above mass to its position of equilibrium. The frequency of the resulting vibration is

$$\frac{1}{2\,\pi}\sqrt{\left\{\frac{10^6\,\times\,7{\cdot}5}{\cdot65}\right\}} = 541.$$

With the aid of a special electric maintenance the plate may be made to *speak* on its own account. The frequency so found, viz., 896, corresponds undoubtedly to a free vibration, but it does not follow that the vibration is the gravest of which the plate is capable; and there were indications pointing to the opposite conclusion.

As it is almost impossible to form *a priori* an estimate of the amplitude of vibration (x) when the frequency of the force is in the neighbourhood of any of the free frequencies, I will take for calculation the case of frequency 256, which is presumably much lower than any of them. Under these circumstances an "equilibrium theory" may be employed, the displacement co-existing with any applied force being the same as if the force were permanent. At this pitch the minimum current recorded in the table† is $8{\cdot}3\,\times\,10^{-7}$ ampères; so that by (12) the maximum excursion corresponding thereto is given by $x = \cdot080\,\times\,8{\cdot}3\,\times\,10^{-7} = 6{\cdot}8\,\times\,10^{-8}$ centim.

The excursion thus found must not be compared with that calculated formerly‡ for free progressive waves. The proper comparison is rather between the *condensations*, s, in the two cases. In a progressive wave the connection between s and v, the maximum velocity, is $v = a\,s$, where a is the velocity of propagation. But in the present case the excursion, x, takes effect upon a very small volume. If A be the effective area of the plate, and S the whole volume included between the plate and the tympanum of the ear, we may take $s = \mathrm{A}\,x/\mathrm{S}$. This relation assumes that the condensations and rarefactions are uniform throughout the space in question, an assumption justified by the smallness of its dimensions in comparison with the wave-length, and further that the behaviour is the same as if the space were closed air-tight. It would seem that a slight deficiency in the latter respect would not be material.

For the numerical application I estimate that $\mathrm{A} = 4$ sq. centim., $\mathrm{S} = 20$ cub. centim.; so that with the above value of x

$$s = 1{\cdot}4\,\times\,10^{-8}, \qquad (13)$$

s being reckoned in atmospheres.

The value of s corresponding to but just audible progressive waves of frequency, 256 was found to be $5{\cdot}9\,\times\,10^{-9}$, in sufficiently good agreement with (13).§

But if the equilibrium theory be applied to the notes of higher pitch, such as 512, we find the actual sensitiveness of the telephone

* *Phil. Mag.* xxiii., p. 225 (1887).
† Ewing, "Magnetic Induction," 1891, p. 136.
‡ I should say that these estimates were all made in ignorance of the result to which they would lead.

* "Theory of Sound," 2nd ed. § 221 *a*.
† See preceding paper.
‡ *Proc. Roy. Soc.*, Vol. xxxvi., p. 248 (1877).
§ I hope shortly to publish an account of the observations upon which this statement is founded.

greater than according to the calculation. In this case $\Gamma^* = 7 \times 10^{-8}$; so that by (12)

$$x = 5{\cdot}6 \times 10^{-9},$$

and
$$s = A\,x/8 = 1{\cdot}1 \times 10^{-9} \qquad (14)$$

decidedly smaller than that ($4{\cdot}5 \times 10^{-9}$) deduced from the observations upon progressive waves. The conclusion seems to be that for these frequencies the equilibrium theory of the telephone plate fails, and that in virtue of resonance the sensitiveness of the instrument is specially exalted.

I will not dwell further upon these calculations, which involve too much guesswork to be very satisfactory. They suffice, however, to show that the "push and pull" theory is capable of giving an adequate account of the action of the telephone, so far at least as my own observations are concerned. But it is doubtful, to say the least, whether it could be reconciled with estimates of sensitiveness such as those of Tait and of Preece.

NEW PATENTS—1894.

16,278. "Improvements in and connected with electrical measuring instruments, organs, electrolysis, and working aluminium." J. Swinburne. Dated August 27th.

16,280. "Utilisation of the rise and fall of the tides through the medium of floating and falling 'caissons' or drums acting upon a system of multiplying wheels for production of electricity for all purposes." R. M. Craig. Dated August 27th.

16,331. "Improvements in electric organs." P. R. Harrison. Dated August 27th.

16,366. "Heat electric alarm." R. Brown. Dated August 28th.

16,371. Improvements in or appertaining to Corliss valves of steam and other fluid-pressure engines." G. N. Brearley and A. Brearley. Dated August 28th.

16,389. "Improvements in grapnels for use when lifting or laying cables and the like." J. Skinner. Dated August 28th.

16,391. "Improvements in electrical switches." W. P. Theebmann and G. C. Elliott. Dated August 28th.

16,393. "Improvements in the construction of Corliss valves and trip-gear for steam engines." J. Pollit and E. Wigzell. Dated August 28th. (*Complete.*)

16,400. "Improvements in apparatus for generating and applying electricity to the human body." W. J. Newton, H. J. Purbrook, and H. de C. Hudson. Dated August 28th. (*Complete.*)

16,408. "Improvements in printing telegraphs." R. A. Fowden. Dated August 28th. (*Complete.*)

16,418. "Improvements in and connected with telephonic apparatus." J. Cerpaux and G. de l'Escaille. Dated August 28th. (*Complete.*)

16,423. "Improvements in or applicable to electric lamps." R. J. Rae. Dated August 28th.

16,425. "Improvements in electric accumulators or storage batteries." D. Young. (Communicated by The Hess Storage Battery Company, United States.) Dated August 28th. (*Complete.*)

16,473. "An improved system or method of arranging telephones and appliances in connection with the same, by which no currents are required either for calling for or notifying the completion of communications to the different subscribers, both the above-named signs being given automatically." G. Ritter. Dated August 29th. (*Complete.*)

16,491. "Improvements applicable to gas lights and other lights." T. Barker. Dated August 30th.

16,532. "An improved switch or key for electric glow lamps." W. E. Conze. (Communicated by the Firm of F. W. Busch, Germany.) Dated August 30th.

16,540. "Improvements in apparatus for firing mines electrically." C. A. Terrey. Dated August 30th.

16,542. "Improvements in or connected with searchlight projectors." J. B. Furneaux and H. Walker. Dated August 30th.

16,599. "Regulating electric currents." L. B. Miller. Dated August 31st.

16,606. "Improvements in or connected with carbons for electric arc lights." H. C. Barker, Jun. Dated August 31st.

16,686. "Improvements in the construction of galvanic cells." C. Vogt. Dated September 1st.

16,687. "Improvements in electric alarums." C. Vogt. Dated September 1st.

16,695. "Improvements in electric lighting and extinguishing devices for gas lamps." S. Bruck. Dated September 1st. (*Complete.*)

16,696. "Improvements in or relating to electro-depositing apparatus." H. Le R. Bridgman. Dated September 1st.

16,697. "Improvements in or relating to electro-depositing apparatus and to products obtained thereby." H. Le R. Bridgman. Dated September 1st.

16,710. "An electric lighting apparatus to be used in connection with gas burners." L. Eliasson. Dated September 1st.

* See preceding paper.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1893.

10,441. "Conduit electric railway." E. T. Hughes. (A communication by W. R. De Voe, of America.) Dated May 27th. Claims:—1. In an electric railway the combination with an inclined road bed of longitudinal base blocks in the centre of bed, the inner meeting edges of said blocks being on a plane above the car tracks, the outer edges of said blocks being secured by a triangular strip fastened to the cross ties, and their upper surfaces declining outward and having thereon a line conductor and track supporting a horizontal trolley connected with a car. 2. In an electric railway the combination with an inclined road bed, having a conductor and track mounted thereon, of a horizontal trolley consisting of metal wheels engaging the conductor, and an insulated wheel engaging the track, said wheels being connected on their side by yielding plates holding the trolley in position on the tracks and conductor and to the car. 3. In an electric railway the combination with an inclined road bed having a conductor and grooved track thereon, of horizontal trolley wheels engaging the conductor, and an insulated wheel engaging the track, said wheels being united on each side by journals in triangular yielding plates, said plates being connected by a tension spring on one of their sides and to the car by a contact post.

10,569. "Improvements in means or apparatus for regulating the temperature of electrical heating, cooking, or like apparatus." R. E. B. Crompton and H. J. Dowsing. Dated May 30th. In some forms of electrical heating and cooking apparatus where it is desired, one or more electrical circuits are arranged with cut-off switches or other devices, so that when the apparatus is first set to work several such circuits are switched into parallel with one another, and the rate at which the apparatus is heated up, as well as the consumption of energy, is thereby increased. As soon as the desired temperature is obtained, a series of automatic switches operate and cut off the current. 5 claims.

11,426. "Electric motor." H. L. Todd and G. Lewis. Dated June 10th. Consists of a series of magnets surrounding a shaft. Each magnet placed with its poles outwardly, so as to induce or attract an armature which is to revolve around the outside of the magnets. These magnets are arranged so as to form two sets of seven magnets each, each set being bolted or fastened to an outside casing, which forms one end of the motor's frame. 16 claims.

12,153. "Improvements relating to methods of measuring, controlling, and regulating electric currents, and to apparatus therefor." A. G. Waterhouse. Dated June 20th. The inventor combines with the circuit the current in which he wishes to regulate another circuit in which is included one or more electrolytic cells made with suitable materials. A current will only flow through the regulating circuit when the potential difference at the terminals thereof exceeds a certain value, hence he so arranges that when the current in the main circuit is altered, the potential difference at the terminals of the regulating circuit shall be altered so that a current shall flow through or cease to flow through the said regulating circuit. 10 claims.

13,217. "Improvements in secondary electric batteries." The Lithanode and General Electric Company, Ltd., and J. T. Niblett. Dated July 6th. Relates specially to solid secondary electric batteries as described in Specification No. 14,411, September 12th, 1890. The object of the present invention is to combine with the advantages of such a battery the advantages also of the active material called "lithanode." 2 claims.

13,336. "Improvements in the electrolytical production of nickel and other metals." C. Hoepfner. Dated July 8th. Solutions of nickel are purified from cobalt and other metals more electro-negative than nickel contained therein. Then they are electrolysed in a neutral state or acidulated by weak acids of small electrolytical conductivity, for instance, citric acid and phosphoric acid and the like. The electrolysis takes place by means of insoluble anodes, immersed in a solution of metal or of metals more electro-positive than nickel, and commonly separated from the cathodes by a membrane strong enough to resist chemical and mechanical actions. The inventor uses porous diaphragms of nitrated linen or cotton cloth, sometimes combined with asbestos. 7 claims.

13,412. "Improvements in automatic regulators for electric generators." E. Conrady. Dated July 11th. The inventor employs a solenoid or electro-magnet, the same being suitably wound and connected to the generator, so that its core or armature will be moved either in one direction or the other by any deviation of the said generator from its normal working condition, and this motion of the core or armature he employs for actuating reversing mechanism driven by a separate and additional motor. 11 claims.

14,091. "Improvements relating to electric fuses." F. W. T. Brain. Dated July 21st. The inventor substitutes for phosphide of copper, silver and platinum; thus resulting in a chemical composition, consisting of chlorate of potash, sulphide of antimony, silver, and platinum in suitable proportions intimately mixed. 1 claim.

14,202. "Improvements in multipolar dynamo electric generators and motors." L. Pyke and E. S. Harris. Dated July 22nd. The field is constructed of a single exciting coil contained within a deep annular channel formed in a single magnetic mass which surrounds the exciting coil more or less completely, and is provided upon the opposite walls of and within said channel with two rings or sets of rings of magnetic material furnished with or forming polar extensions also under the direct influence of the exciting coil, the said rings are built up of iron laminæ fitting in or on the walls of the channel, or one or both of them may form part of the magnetic mass which as well as the polar extensions may be of cast or wrought iron or steel. 2 claims.